Operations Report

U.S. Geological Survey

Ironton Project
Southeast Missouri

Airborne Horizontal Magnetic Gradient and Radiometric Survey

March 30, 2016

Report #: B-438

Requested By:
Anne McCafferty
U.S. Geological Survey
Crustal Geophysics and Geochemistry Science Center

USGS Contract No. G16PC00002

Prepared by:
Charles Barrie, Managing Partner
Terraquest Ltd.

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1. Introduction

1.1. Executive Summary

This report describes the specifications and parameters of an airborne geophysical survey carried out for:

U.S. GEOLOGICAL SURVEY
Crustal Geophysics and Geochemistry Science Center
Box 25046, Mail Stop 964, Denver Federal Center
Denver, CO 80225

Attention: Anne McCafferty
Tel: 303-236-1397 Email: anne@usgs.gov

The survey was performed by:

TERRAQUEST LTD.,
2-2800 John Street, Markham
ON, Canada
L3R 0E2

Tel: 905-477-2800 Email: cb@terraquest.ca.

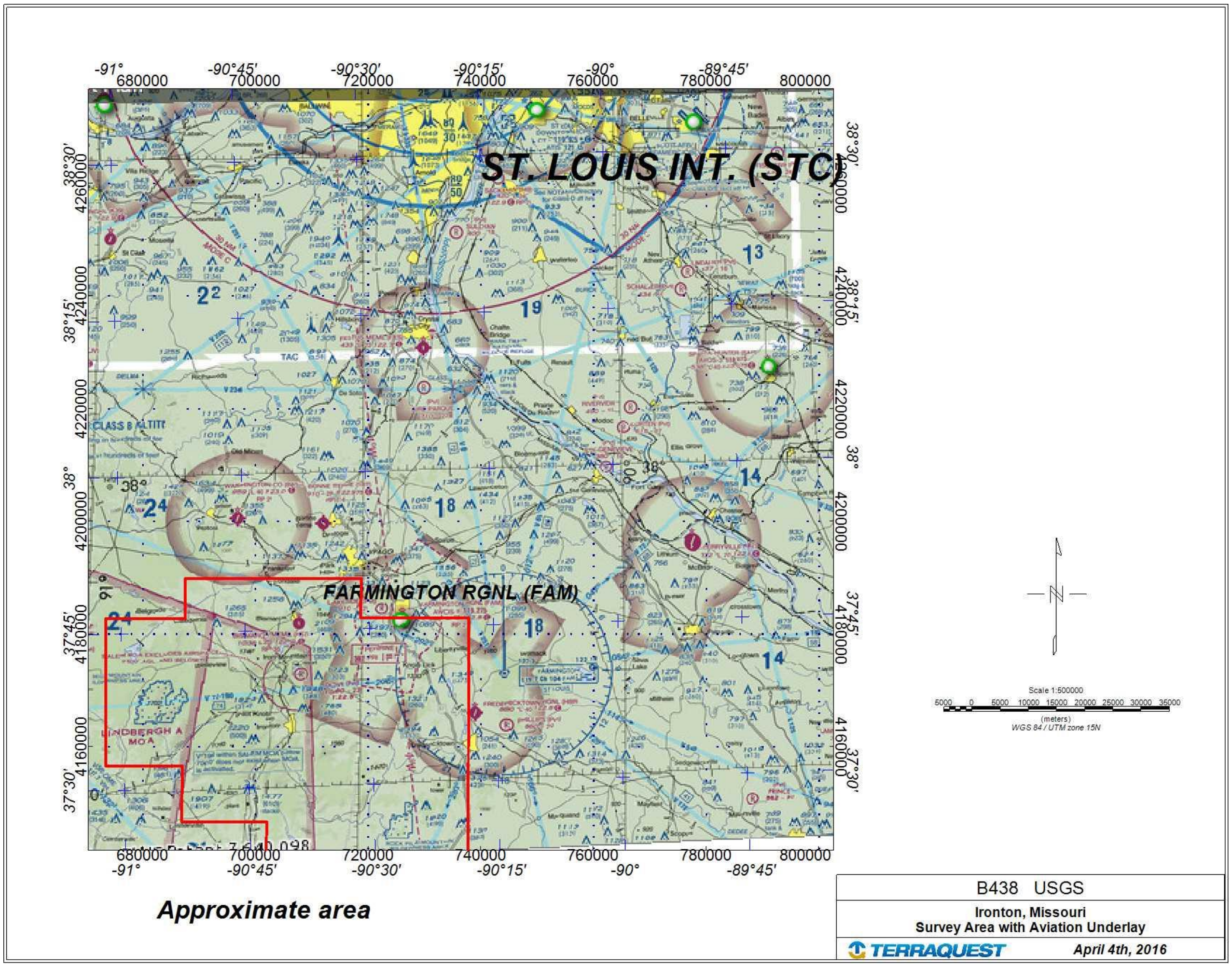
The purpose of the survey of this type is to collect geophysical data for ongoing research of mineral resources. Magnetic and Radiometric responses can be used to guide mineral characterization by using the contoured patterns of the geophysical data to make interpretations regarding the surface and subsurface geology and structure. The data are carefully processed and contoured to produce grid files and maps that show distinctive patterns of the geophysical parameters.

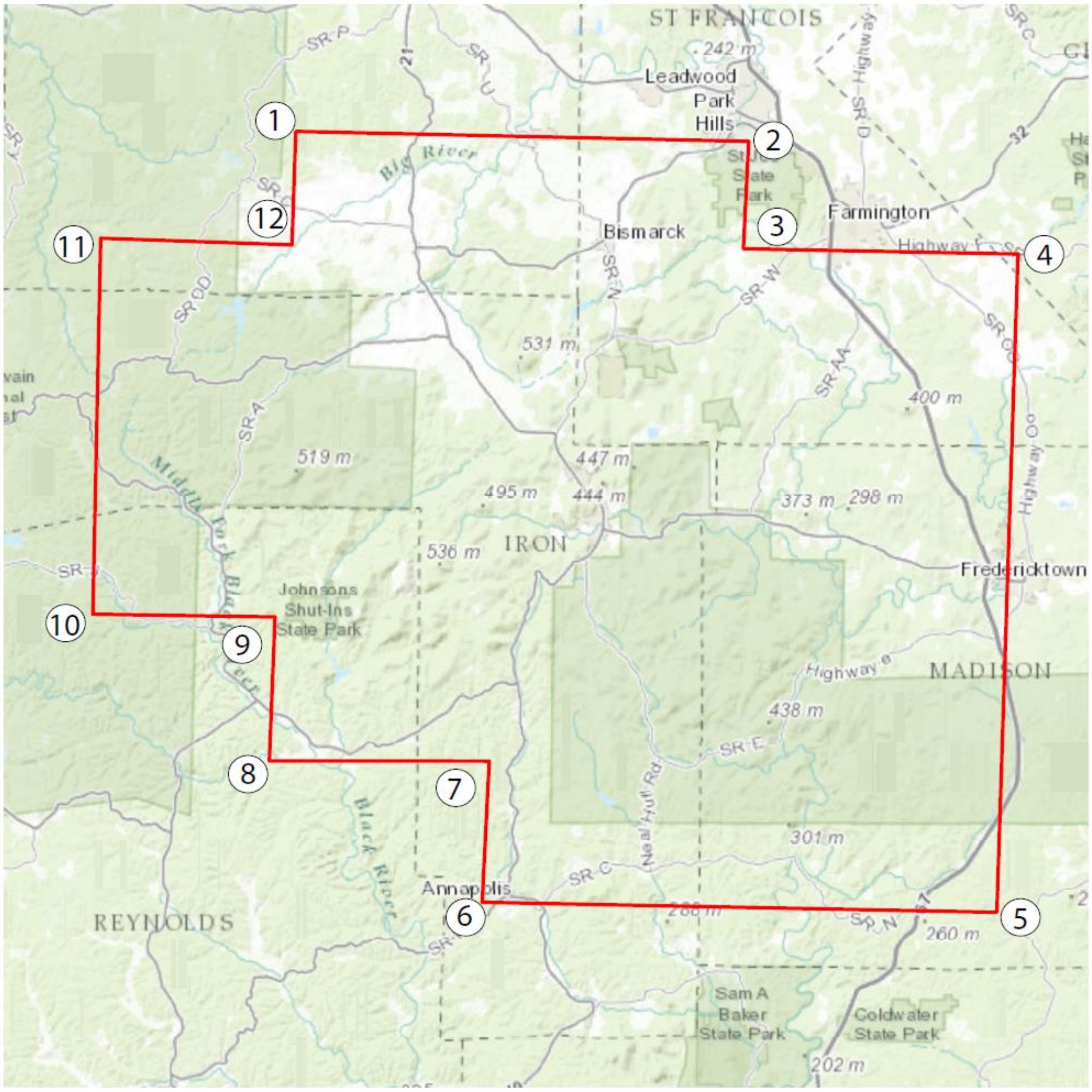
To obtain this data, the area was systematically traversed by an aircraft carrying geophysical equipment along parallel flight lines. The lines are oriented to intersect the geology and structure so as to provide optimum contour patterns of the geophysical data.

1.2. Location

The survey is located in south eastern Missouri, United States, approximately 100 kilometres south of St. Louis. The town of Farmington lies in the northeast corner of the survey block, Fredericktown along the eastern boundary, and Annapolis along the southern boundary. The survey area includes parts of Madison, Iron, St. Francois, Reynolds and Washington Counties.

The survey is generally rectangular in shape with cutouts in the northeast, southwest and northwest; there are a total of 12 corners. The maximum east-west dimension is 54 kilometres (34 miles) and the maximum north-south dimension is 53 kilometres (33 miles). The centre of the area is approximately 37 degrees 37 minutes north and 90 degrees 38 minutes west.


ST. LOUIS INT. (STC)
FARMINGTON RGNL (FAM)
Approximate area
Scale 1:500000
(meters)
WGS 84 / UTM zone 15N
B438 USGS
Ironton, Missouri
Survey Area with Aviation Underlay
TERRAQUEST
April 4th, 2016

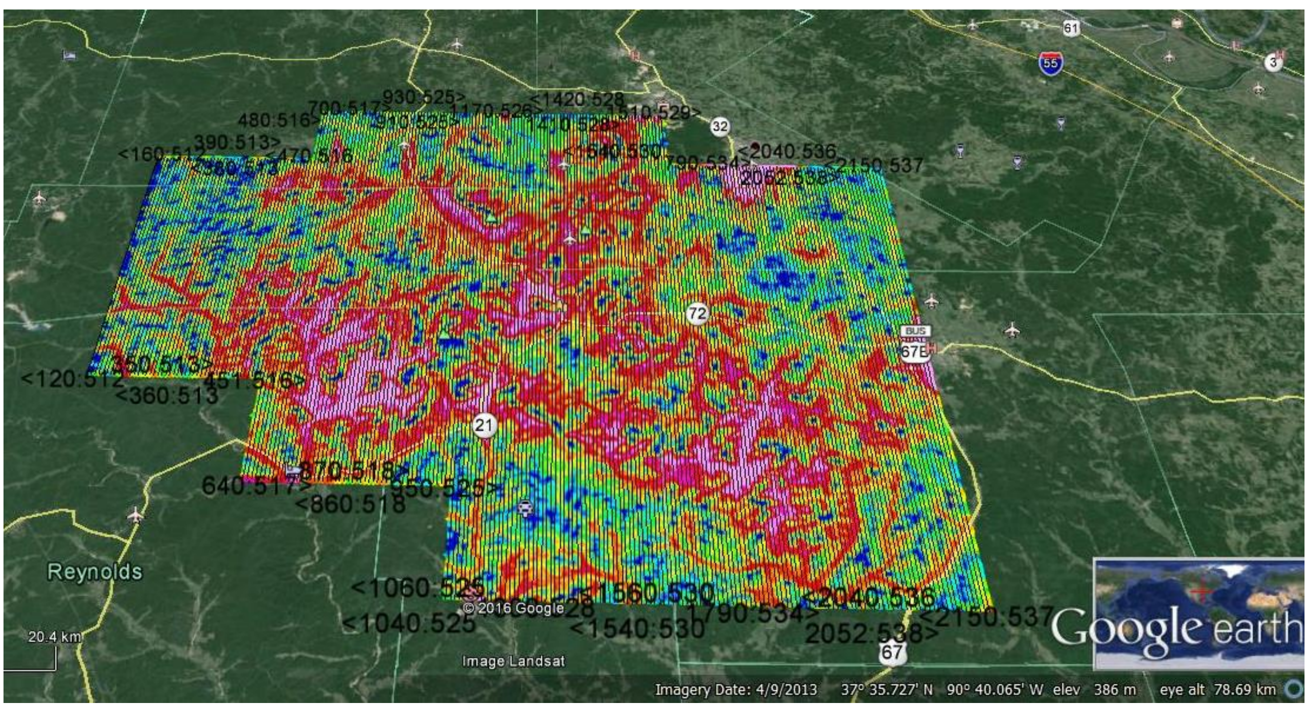

ST FRANCOIS
Leadwood
Park
Hills
Farmington
Bismarck
IRON
Fredericktown
MADISON
REYNOLDS
Johnsons
Shut-Ins
State Park
Annapolis
Sam A
Baker
State Park
Coldwater
State Park
Big River
Middle Fork Black River
Black River
Neal Huff Rd
1
2
3
4
5
6
7
8
9
10
11
12
531 m
519 m
495 m
447 m
444 m
536 m
373 m
298 m
400 m
438 m
301 m
260 m
202 m
242 m

2. SURVEY PARAMETERS

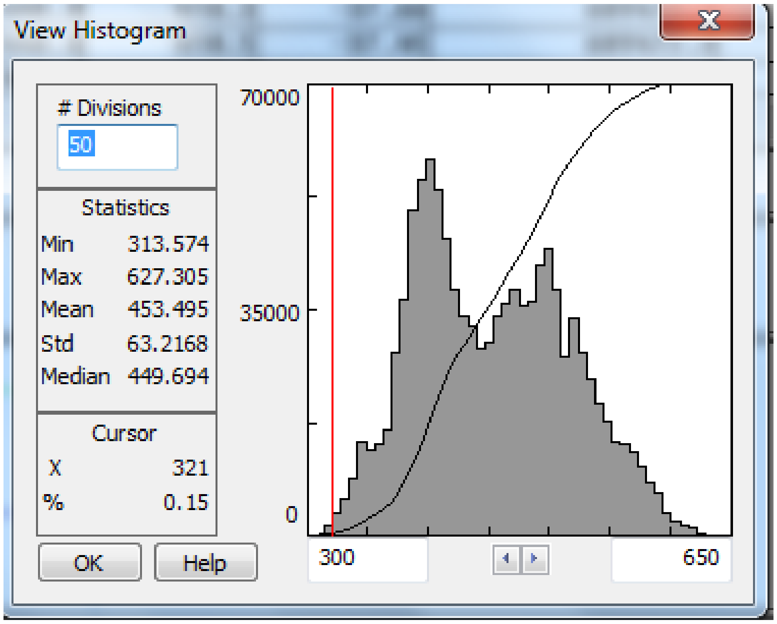
2.1. LINES AND DATA

Parameter	Maurice Creek
Aircraft Speed	mean 74 m/sec 266 km/hr
Magnetic Sampling Interval	7-8 m (10Hz)
Radiometric Sample Interval	70-80 m (1Hz)
Flight-line Interval	300 m
Flight-line Direction	000/180 degrees
Control-line Interval	3000 m
Control-line Direction	090/270 degrees
Preplanned Drape surface	100 m over highest obstacle
Mean Terrain Clearance	140.7 metres*

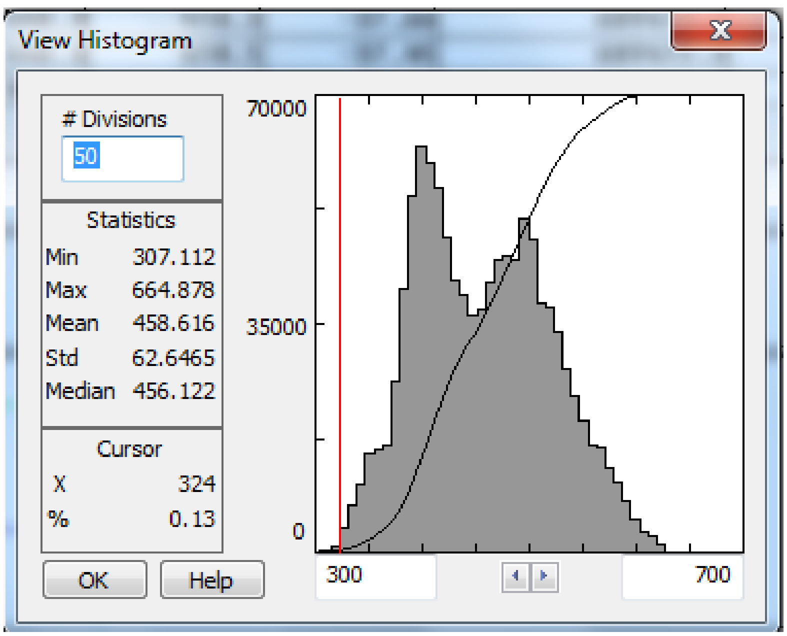
*Mean terrain clearance takes into account valleys too narrow to enter and towns that require a higher terrain clearance (note higher clearances over towns, airports and valleys shown below in red).



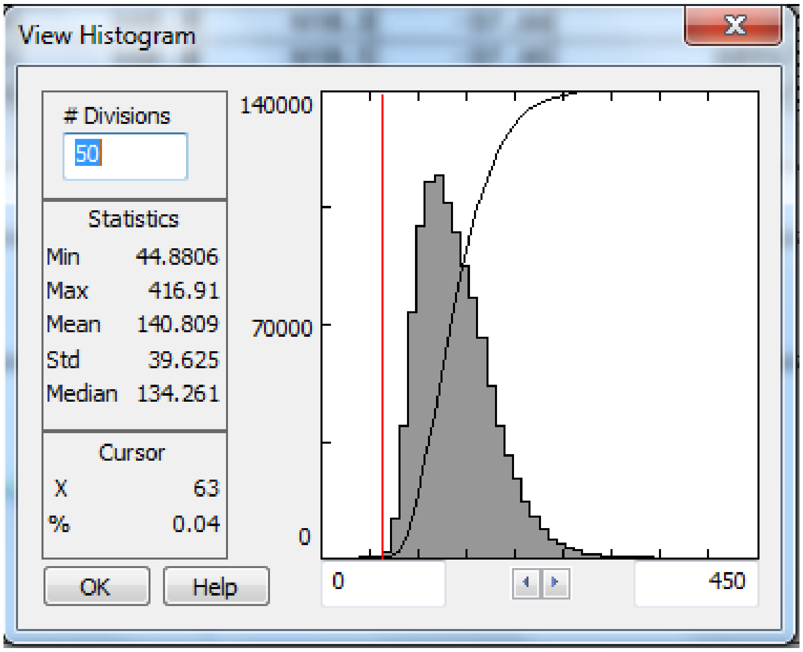
Computer Generated Flight Drape Surface (metres above geoid)



Statistics for drape surface flown (GPS metres above geoid)



Terrain Clearance flown statistics (Radar metres above ground)



2.2. SURVEY KILOMETRAGE

Number of Lines	Ironton Project, MO
215 Survey Lines	9,288.2 km
18 Control Lines	964.9 km
233 Total Lines	10,253.1 km

2.3. NAVIGATION

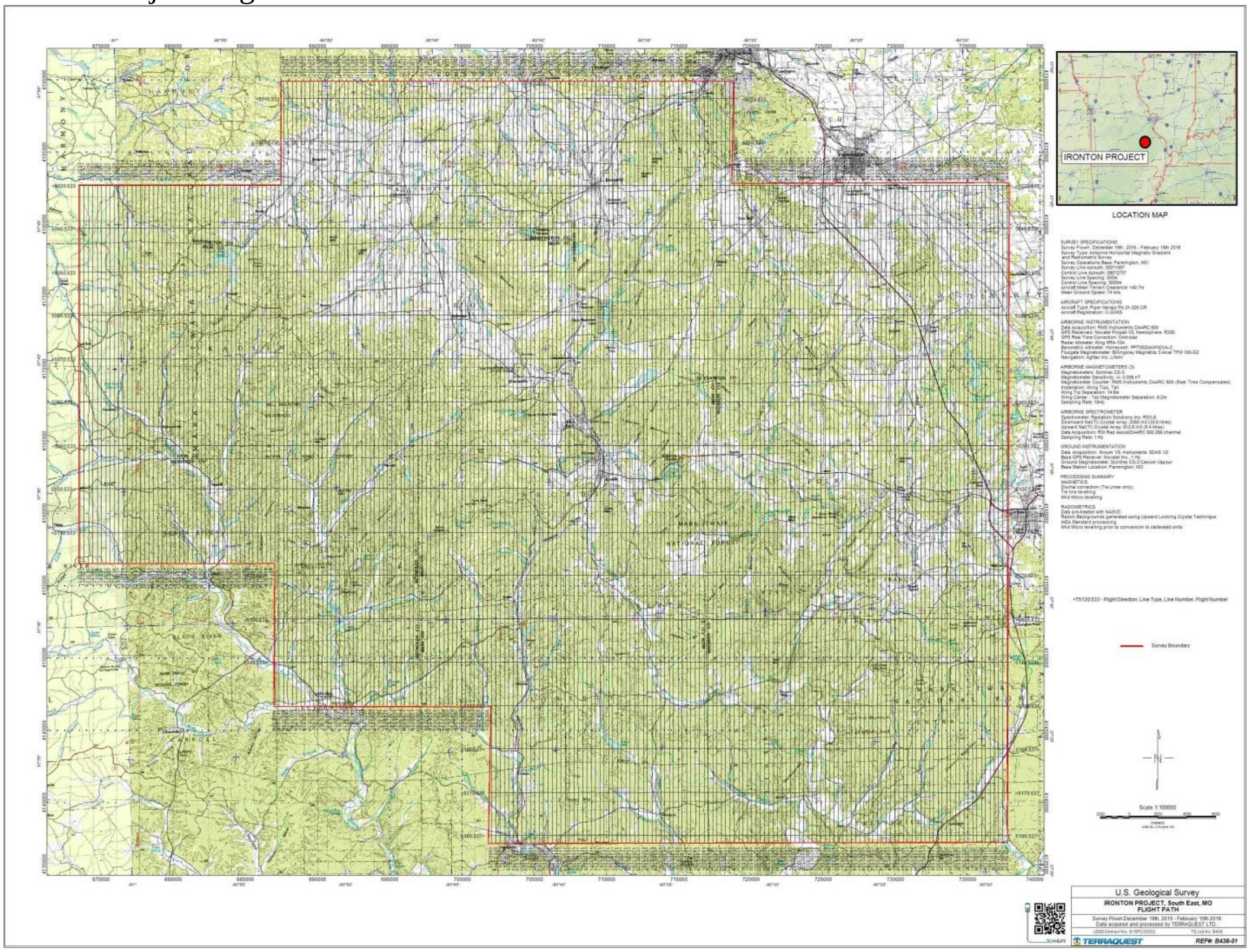
The following file is the navigation parameter file (*.nme) for the survey lines, in WGS84 projection zone 15N, and includes line spacing, line direction, master line and other navigational parameters.

The satellite navigation system was used to ferry to the survey site and to survey along each line. The survey coordinates were supplied by the client and were used to establish the survey boundaries and the flight lines. The flight path guidance accuracy is variable depending upon the number and condition (health) of the satellites employed; the uncorrected accuracy was for the most part better than 10 metres. Real-time GPS correction using the WAAS satellite broadcast services for North America improves the navigational accuracy to about 3 metres or less in the horizontal plane and 4-5 metres in the vertical direction.

```
0  B438
1  U 267
2      687614     4189929       AREA CORNER 1
2      719139     4189929       AREA CORNER 2
2      719139     4182723       AREA CORNER 3
2      738054     4182723       AREA CORNER 4
2      738054     4137187       AREA CORNER 5
2      701825     4137187       AREA CORNER 6
2      701825     4146700       AREA CORNER 7
2      686813     4146700       AREA CORNER 8
2      686813     4156502       AREA CORNER 9
2      673500     4156502       AREA CORNER 10
2      673500     4182723       AREA CORNER 11
2      687614     4182723       AREA CORNER 12
3      687502     4146037   WP1 WAYPOINT 1
3      687188     4145828  COR1 WAYPOINT 2
4         215                NUMBER OF LINES
5        300.0               SPACING, m
8          75               MAX CROSS TRACK, m
9    0  0  0                DELTA X/Y/Z
10          1               LOG FPR EVERY 1 SECS
11 0.9996000000       0.0       0.0 K0, X/Y SHIFT
14         200               LINES EXTENDED BEYOND AREA
16          10              FIRST LINE NUMBER
17   738054.0   4137187.0   0.0 MASTER POINT, HEADING
18   738054.0   4137700.0  90.0 TIE LINE MASTER POINT, HEADING
19     3000.0       200        TIE LINE SPACING, LINE EXTENSION, m
20 WGS-84      6378137.0   298.257223563 22       ELLIPSOID
21          0               NO EQUATORIAL CROSSING, N HEMISPHERE
30         20    9600  N  1  8  RS-232 PORT 2 INCOMING FORMAT
31         20    9600  N  1  8  RS-232 PORT OUTGOING FORMAT
38          0               METRIC SYSTEM
41        0.00               SYSTEM LAG, Secs.
80        0.00               PLANNED ALTITUDE, m
83          0               GPS ALTITUDE FOR VERTICAL BAR
84        0.00        0.00      ALTITUDE COEFFICIENT, OFFSET
85         100               MAX VERTICAL BAR SCALE
102  UTM                     UTM X/Y SCALE
```

2.4. FLIGHT PATH

Ironton Project Flight Path



2.5. TOLERANCES - REFLIGHT

1. **Traverse Line Interval**

   Contract specifications mandate that re-flights would take place if the flight line separation of the final differentially corrected flight path exceeds 1.2 times or not be less than 0.8 times intended line separation over a distance greater than 3 times the traverse line separation.

2. **Terrain Clearance:**

   Contract specifies that the survey shall be flown with a tight drape fashion with as low a nominal terrain clearance as safety permits (~ 100 metres best efforts) to optimize the magnetic data.

Re-flights were done if the final differentially corrected altitude deviated from the agreed flight surface by +/-15m over a distance of 2 kilometres.

3. Diurnal Variation:

Diurnal activity in the survey was limited to 3 nT deviations from 1-minute chord.

4. GPS Data:

GPS data included at least 4 satellites 15 degrees over horizon for navigation and flight path recovery.

5. Radio Transmission:

The aircraft pilot made no radio transmission that interfered with magnetic response unless mandated by airport or air traffic safety situations.

6. Sample Density:

A reflight is required if the sample density along one or more of the survey lines exceeds 8 metres over a cumulative total of 1000 metres for the magnetic data, and 80 metres over a cumulative total of 1000 metres for the radiometric data.

7. Magnetic Noise:

The contract mandates that the fourth difference noise envelope for the tail sensor data does not exceed +/- 0.10 nT.

8. Measurement Gaps:

There were no significant gaps in any of the digital data including GPS, radiometric and magnetic data.

3. AIRBORNE GEOPHYSICAL EQUIPMENT

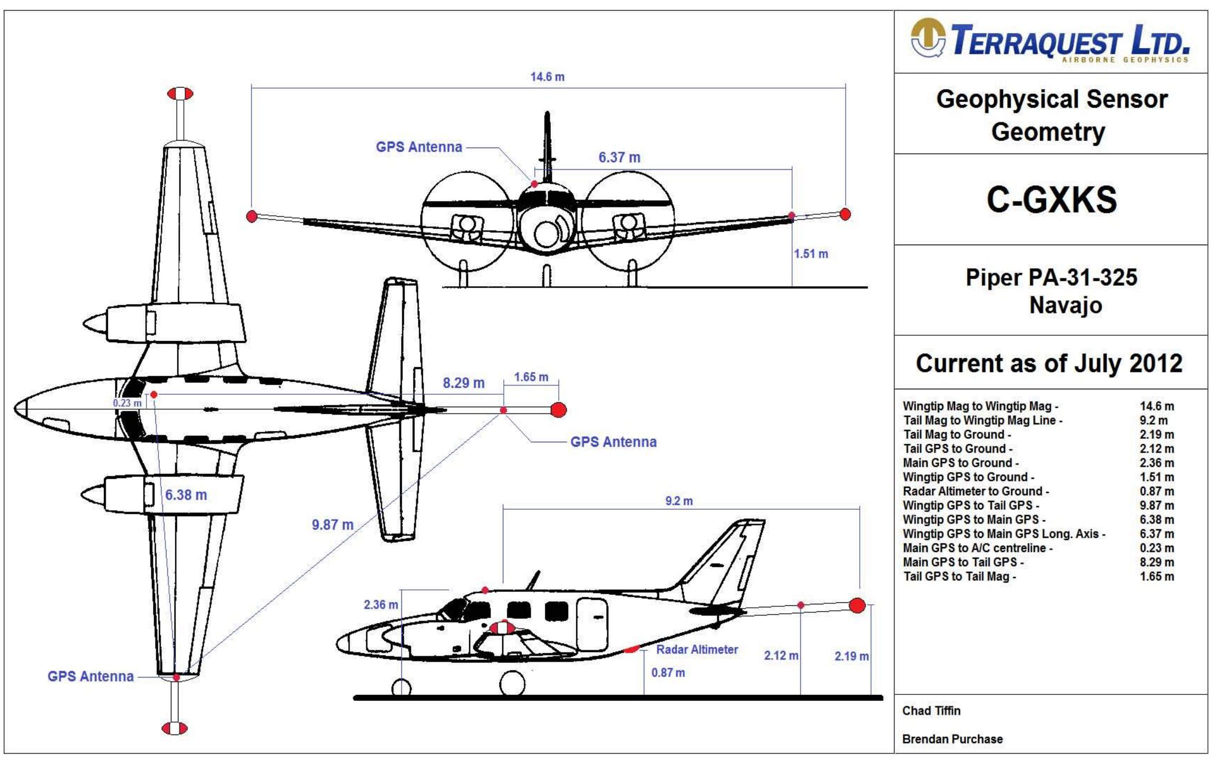
The primary airborne geophysical equipment includes three high sensitivity cesium vapour magnetometers, a fully calibrated gamma ray spectrometer, and an optional, recently developed digital VLF-EM system. Ancillary support equipment includes a tri-axial fluxgate magnetometer, data acquisition system, radar altimeter, barometric altimeter, three GPS receivers, real-time GPS correction service and a navigation system. The navigation system comprises a left/right indicator for the pilot and a screen showing the survey area, planned flight lines, and the real time flight path. All data were collected and stored by the data acquisition system. Section 3.1 shows a summary of the geophysical equipment, Section 3.2 shows aircraft specifications, and Section 3.3 provides detailed geophysical equipment specifications.

3.1. EQUIPMENT SUMMARY

Aircraft	Piper Navajo PA 31-325 CR
Equipment:	
Magnetometers (3)	Scintrex : CS-3 Cesium Vapour
Fluxgate 3-axis Magnetometer	Billingsley Inc.: TFM100-LN
Gamma Ray Spectrometer	Radiation Solutions: RS-500
VLF-EM Receiver (optional)	Magenta Inc.: Matrix
Kinematic Grade GPS Receivers	Hemisphere: R320, Novatel: ProPak V3
Radar Altimeter	King: KRA 10A
Barometric Altimeter	Honeywell: PPT0020AWN2VA-C
Data Acquisition & Mag Counter	RMS Instruments: DAARC system

3.2. SURVEY AIRCRAFT

The Survey Aircraft for this project was a Navajo PA31-325 CR, owned and operated by Terraquest Ltd. The aircraft has been specifically modified with long-range fuel cells and an array of sensors to carry out airborne geophysical surveys.



3.3. SURVEY EQUIPMENT AND SPECIFICATIONS:

1. High Sensitivity Magnetometer:

One high-resolution cesium vapour magnetometer is mounted in the tail stinger and two are located in wing tip pods. A fluxgate tri-axial magnetometer is mounted in front of the tail stinger to monitor aircraft manoeuvre and magnetic interference; this data is used post-flight to compensate the high sensitivity data for aircraft manoeuvre noise.

Type of Magnetometer Sensor	Cesium Vapour
Model	CS-3
Manufacturer	Scintrex Ltd.
Resolution	0.001 nT counting at 0.1 per second
Sensitivity	+/- 0.005 nT
Dynamic Range	15,000 to 100,000 nT
Fourth Difference	0.02 nT
Recorded Sample Rate	0.1 seconds
Noise Envelope	0.10nT (Tail Mag)
Sensor Orientation	vertical

2. Tri-Axial Fluxgate Magnetic Sensor

Tri-Axial Fluxgate Magnetic Sensor	(for compensation, mounted in mid-section of tail stinger)
Model	W/FM100G2-1F
Manufacturer	Billingsley Magnetics
Description	Low noise miniature triaxial fluxgate magnetometer
Axial Alignment	> Orthogonality > +/- 1 degree
Accuracy	< +/- 0.75% of full scale (0.5% typical)
Field Measurement	+/- 100,000 nanotesla
Linearity	< +/- 0.015% of full scale
Sensitivity	100 microvolt/nanotesla
Noise	< 12 picotesla RMS/–Hz @ 1 Hz

3. Radar Altimeter

Altimeter	Radar
Model	KRA-10A
Manufacturer	King
Serial Number	071-1114-00
Accuracy	5% up to 2,500 feet
Calibrate Accuracy	1%
Output	Analog for pilot, converted to digital for data acquisition

4. **Barometric Sensor**

Sensors	Pressure (mB)
Model	PPT0020AWN2VA-C
Manufacturer	Honeywell
Source	coupled to aircraft barometric (pitot static) system
Output	Serial output to DAARC 500 channels 3 & 4 respectively

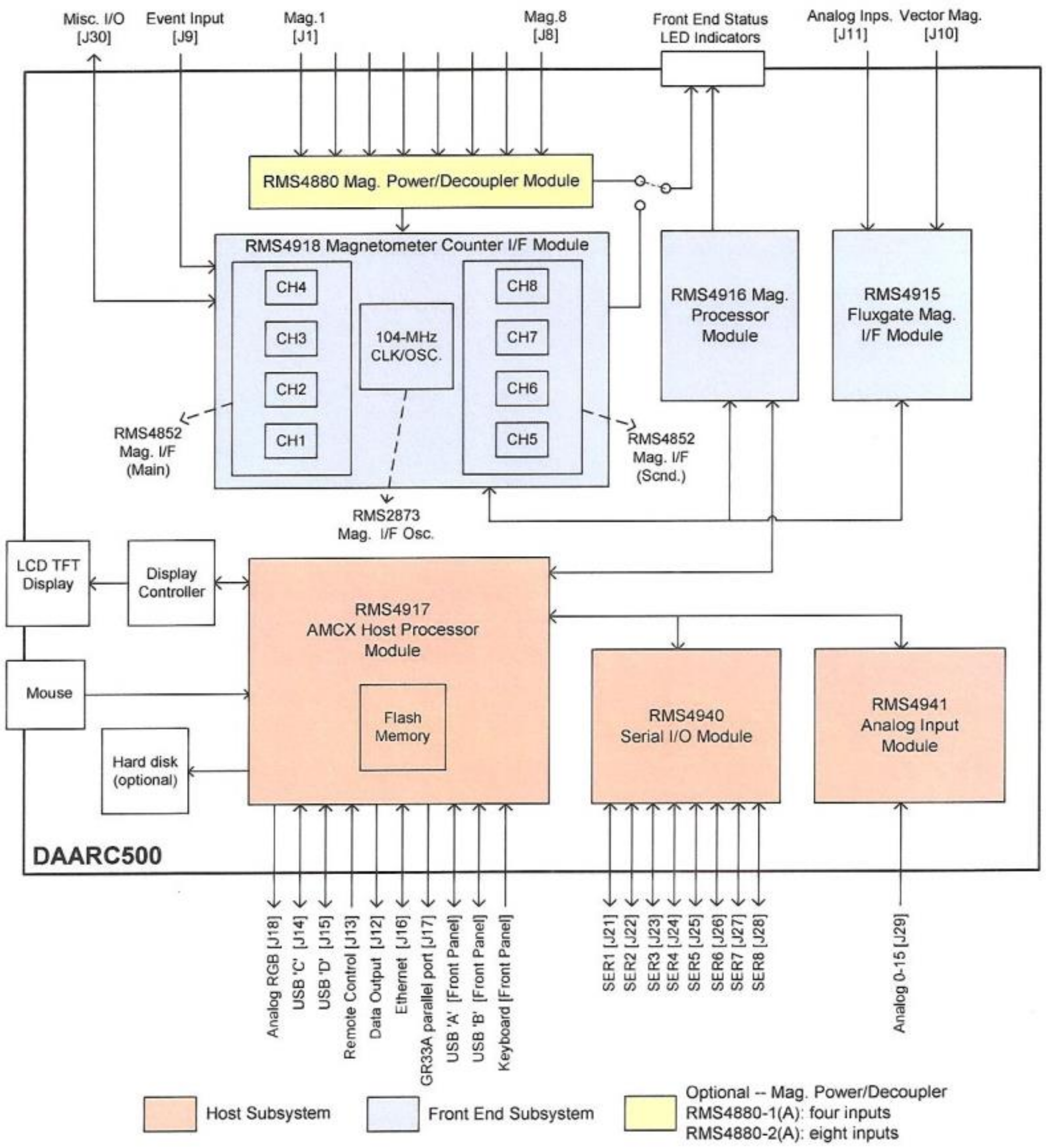
5. **Radiometric System (2 5-packs)**

Type	Gamma Ray Spectrometer
Model	RS 500
Manufacturer	Radiation Solutions Inc.
Serial Numbers	5587, 5588
Crystal Manufacturer	Saint-Gobain
Downwards Volume	2050 in^3 (33.6 litres) Downward (8 crystals)
Upwards Volume	512 in^3 (8.4 litres) Upward (2 crystals)
Software	Real Time Data Collection
Energy Detection Range	50KeV to 3 MeV
Count Rate	Up to 1000,000 pps communication
RSI Native Spectra	1024 Channels
Output Spectra	512 Channels Up and Down
Sampling Rate	1 Hz, no dead time
Automatic Gain Stabilization	Thorium
Energy Resolution	< 8.5%

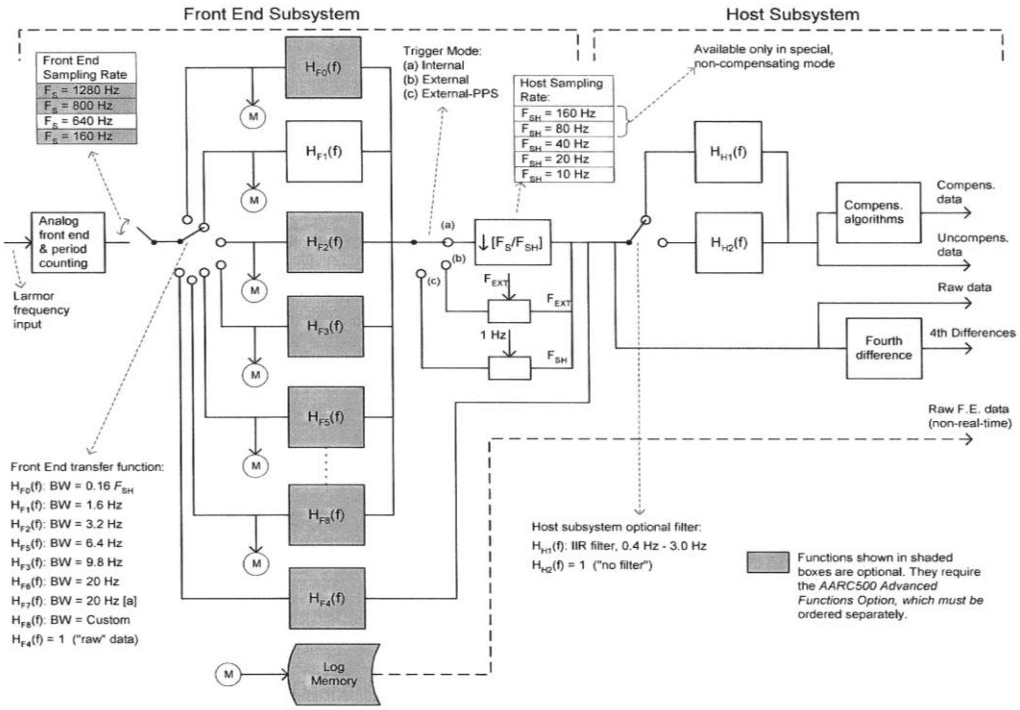
6. **Data Acquisition System**

DAS & Compensation	Combined
Model	DAARC 500
Manufacturer	RMS Instruments
Operating System	QNX 6.3 or greater
Time	104 MHz temperature compensated crystal clock
Front End Magnetic Processing	Resolution 0.32pT; system noise <0.1pT; sample rate 160, 640, 800m or 1280 Hz
Front End - Fluxgate	I/F module; oversampling, self-calibrating 16 bit A/D converter
Compensation	Improvement Ratio (total field) 10-20 typical
Input Serial	8 isolated RS232 channels; ASCII & Binary formats
Input Analog	16 bit, self-calibrating A/D conv.
Input Events	Four latched event inputs
Raw Data Logging	At front end sampling rate, 1 MB buffer
Output/Recording	Rate 10 (used), 20 or 40 Hz; Serial up to 115.2 kbps; Recording media 1 GB Flash; 80 GB Hard Drive; Flash disk via USB; Display
Front Panel Indicators	8 LEDs for mag input; 2 LEDs for Front End status

Simplified block diagram of DAARC 500 (Mag1=left, Mag2=right, Mag3=tail)



Summary of signal processing: DAARC 500



Survey DAARC 500 settings:
- Mag1 = left wingtip magnetometer
- Mag2 = right wingtip magnetometer
- Mag3 = tail singer magnetometer
- Trigger Mode: external-pps
- Front End Sampling: default 640 Hz
- Transfer Function: bandwidth 1.6
- Host Sampling: 10 Hz
- Host Subsystem Filter: none

7. Navigation System

Navigation & Guidance	Stand-alone module
Model	LiNav P151
Manufacturer	AgNav Inc.
Main Display	LCD Moving map display
Pilot Display	2 line shows left/right, dist. to end of line/survey
Line	Generates and follows survey lines
Input	GPS with corrections; up to 10 Hz
Media	USB memory stick

8. Kinematic Grade GPS Receivers

Kinematic GPS Receiver	Antenna located in wing tips (2)
Model	Eclipse R320: L_1L_2/GPS/GLO/Omnistar), kinematic
Manufacturer	Hemisphere
Antenna	Antcom L_1/L_2, L-band, 40 dB
Channels	12
Position Update	0.2 second for navigation
Correction Service	Real time correction broadcast service – WAAS
Sample Rate	0.1 second
Mobile Accuracy	~ 3 meters

Differential GPS Receiver	Antenna located in tail stinger (1)
Model	ProPak V3l differential, kinematic grade s/n 107408
Manufacturer	Novatel Inc.
Antenna	L_1/L_2
Channels	12
Position Update	0.2 second for navigation
Correction Service	Real time correction broadcast service – WAAS
Sample Rate	0.1 second
Mobile Accuracy	~ 3 meters

9. Optional VLF-EM System

VLF-EM System	Newly developed digital system
Model	Matrix Plus
Manufacturer	Magenta Inc.
Antenna	Three orthogonal coils (x,y,z) in right wing tip pod
Primary Sources	4 discrete frequencies (stations)
Parameters	Amplitude, vertical and planar ellipicity, azimuth
Sample Rate	0.1 second
Gain	Constant gain setting
Filtering	No filtering

4. Base Station Equipment

4.1. BASE STATION MAGNETOMETER

High sensitivity magnetic base station data was provided by a split beam cesium vapour magnetometer logging onto a computer and with time synchronization from a GPS base station receiver.

The magnetometer was similar to the type used in the aircraft, a cesium magnetometer manufactured by Scintrex. The magnetometer processor was a KMAG manufactured by Kroum VS Instruments and the data logger was a PDA by Archer. The counter was powered by a 10VAC 50/60 Hz to 30VDC 3.0 amp power supply with an internal 12VDC fan. The logging software SDAS-1 was written by Kroum VS Instrument Ltd. specifically for handheld pc hardware. It supports real time graphics with selectable windows (uses two user selectable scales, coarse and fine). Time recorded was taken from the base GPS receiver. Magnetic data was logged at 1Hz. Data collection was by RS232 recording ASCII string and stored on flash card.

Ground Magnetometer	Cesium Vapour
Model	CS – 3
Manufacturer	Scintrex
Sensitivity	0.005 nT
Noise Envelope	0.05 nT
Sampling Interval	1 second

During the survey period the geophysicist also monitored the Regional Geomagnetic Forecasts for Western North America provided by NOAA websites.

4.2. BASE STATION GPS RECEIVER

The GPS base receiver was used to provide a GPS time stamp to the base station magnetic data.

GPS Differential Receiver	Base Station (1)
Model	ProPak V3 differential, kinematic grade s/n 107408
Manufacturer	Novatel Inc.
Antenna	L_1/L_2
Channels	12
Position Update	0.2 second for navigation
Sample Rate	0.1 second
Accuracy	~ 1.8 meters

5. TESTS AND CALIBRATIONS

5.1. MAGNETIC FIGURE OF MERIT

Magnetic compensation tests were performed to determine the magnetic influence of aircraft maneuvers and the effectiveness of the aircraft compensation method. The aircraft flew a square pattern in the four survey directions at a high altitude over a magnetically quiet area and perform pitches (± 5°), rolls (± 10°) and yaws (± 5°). The sum of the maximum peak-to-peak residual noise amplitudes in the total compensated signal resulting from the twelve maneuvers is referred to as the FOM. The FOM for Ironton survey was done near Farmington, MO on January 5, 2016 with a result for the left, right and tail sensors were respectively 1.30 nT, 0.93 nT and 0.80 nT. Refer to ***9.3 Appendix III – Figure of Merit*** for details.

5.2. MAGNETIC LAG

Evaluation of the magnetic lag factor was accomplished by flying over a clearly identifiable discrete anomaly flown in opposing directions. The measured lag was 0.57 seconds for the tail sensor.

B438 IRONTON C-GXKS : LAG TEST (Repeat Line Pair)

TAIL SENSOR (TF3)			
LINE	**DIR**		**Reference Anomaly**
S241210	N	FIDUCIAL	45701.6
		X	504200.8
		Y	5439035.1
		SPEED (S_1)	65.8
S41220	S	FIDUCIAL	57259.6
		X	504202.7
		Y	5438958.3
		SPEED (S_2)	68.3
		DELTA (apparent directional seperation, metres)	**76.8**
		LAG (secs) *	**0.57**

WINGTIP SENSORS (TF1, TF2)				
LINE	**DIR**		**Reference Anomaly**	
			TF1	**TF2**
S41210	N	FIDUCIAL	45701.4	45701.5
		X	504200.8	504200.8
		Y	5439021.9	5439028.5
		SPEED (S_1)	65.8	65.8
S41220	S	FIDUCIAL	57259.5	57259.6
		X	504202.7	504202.7
		Y	5438965.1	5438958.3
		SPEED (S_2)	68.3	68.3
		DELTA (apparent directional seperation, metres)	**56.8**	**70.2**
		LAG (secs) *	**0.42**	**0.52**
		AVERAGE TF1,TF2 LAG (secs)	**0.47**	

** Lag factor calculated as LAG = DELTA/(S1+S2)*

5.3. MAGNETIC HEADING TEST

A magnetic heading test was flown on site at survey altitude at the Canadian calibration site in Morewood, Ontario on August 13, 2015 as follows:

AEROMAGNETIC SYSTEM CALIBRATION RANGE
AT MOREWOOD, ONTARIO

Project: USGS-IRONTON **TERRAQUEST REF :** B438-IRONTON

Aircraft: C-GXKS
Company: Terraquest LTD
Magnetometer: **Tail Sensor (TF3)** - Cesium Vapour CS-2 - SN 921203
Data Acquisition system: RMS DAARC 500

Date: 13 AUG 2015
Height Flown: ~457m (1500')
Sampling rate: 10 samples / second
Compiled by: Terraquest LTD

Line Number	Azimuth	Fiducial Over Point	TIME			TMI value measured by aircraft over point	Radar Altimeter (metres)	C^H	Blackburn Observatory Diurnal reading at previous minute (T2)	Blackburn Observatory Diurnal reading at subsequent minute (T3)	Interpolated Diurnal reading at time over point T4 =T2+SS * (T3-T2)/60	Calculated Morewood value T5=T4-C+C^H	Error value T6=T1-T5
			HH	MM	SS								
S1040	330°	81317.7	22	35	17.7	53829.06	442.8	-0.6	54464.60	54464.13	54464.53	53825.26	3.80
S1050	150°	82194.1	22	49	54.1	53829.14	438.5	-0.7	54464.87	54464.91	54464.89	53825.45	3.69
S2050	60°	82678.4	22	57	58.4	53828.58	455.0	-0.1	54464.05	54463.98	54464.02	53825.23	3.35
S2040	240°	81901.8	22	45	1.8	53828.33	444.6	-0.5	54463.87	54463.98	54463.87	53824.68	3.65
S1060	330°	83034.1	23	3	54.0	53828.69	450.5	-0.3	54464.05	54463.92	54463.99	53825.03	3.66
S1070	150°	83835.8	23	17	15.8	53828.82	442.6	-0.6	54464.64	54464.49	54464.62	53825.35	3.47
S2070	60°	84168.7	23	22	48.7	53829.18	440.9	-0.6	54464.87	54464.88	54464.87	53825.53	3.65
S2060	240°	83456.4	23	10	56.4	53828.23	448.0	-0.4	54463.73	54464.04	54463.88	53824.81	3.42
												Average:	3.59

C^H is the correction for the height over the ground calculated at receiver height 0.03937 nT/m
C is the difference in the total field between Blackburn Obervatory value (0) and the value B at the intersection point above Morewood at a given height.
At 457.2 m (1500 ft), C= (0-B)= **638.7** nT

Average North-South Heading Difference (T6 North–T6 South) =	0.15	nT
Average East-West Heading Difference (T6 East–T6 West) =	-0.04	nT
Total/Number of Passes =	8	

Mean North – South value=	3.66	nT
Mean East – West value =	3.52	nT
Difference between mean N – S and mean E – W =	0.14	nT

5.4. RADAR ALTIMETER CALIBRATION

A radar altimeter calibration was performed by flying in increments of 100 feet up to an altitude of 800 feet over the runway at Cochrane, ON on November 11, 2015. Least Squares Regression analysis on the resulting data generated the slope/intercept factors required to convert the raw radar altimeter data feed calibrated terrain clearance. The slope was 154.617932 with an intercept of 0.0792. Refer to ***9.4 Appendix IV – Radar Altimeter Calibration*** for a presentation of the results and analysis.

5.5. RADIOMETRIC SENSITIVITY FACTORS

The annual radiometric system sensitivity was determined on July 28, 2015 from measurements acquired over the Breckenridge calibration test site, near Ottawa, Canada. The concurrent ground survey was performed by Terraquest Ltd. personnel using a calibrated ground spectrometer; model R230 by Radiation Solutions Inc. Refer to ***9.9 Appendix IX – Sensitivity Factors*** for details.

5.6. RADIOMETRIC ALTITUDE ATTENUATION

The altitude attenuation factors were calculated using data acquired at Breckenridge calibration site near Ottawa on July 28, 2015. Refer to ***9.8 Appendix VIII – Altitude Attenuation*** for details.

5.7. RADIOMETRIC COMPTON COEFFICIENTS

The annual Compton coefficients were determined by analyzing data acquired over standard radiometric calibration pads by the equipment manufacturer (Radiation Solutions) located in Mississauga, Ontario, Canada. These measurements were performed on July 15, 2015. Refer to ***9.7 Appendix VII – Compton Coefficients*** for details.

5.8. RADIOMETRIC COSMIC CALIBRATION

The cosmic calibration was done at Farmington, MO on December 19, 2015. Refer to ***9.6 Appendix VI – Cosmic Calibration*** for details.

6. LOGISTICS

6.1. PERSONNEL

The contractor supplied the following properly qualified and experienced personnel to carry out the survey and to reduce, compile and report on the data:

Field:	Survey Pilots	Serguey Salnicov
		Rick Smith
	Operator	Jeremy Weber
	Geophysicist	Alan Duffy
Office:	Geophysicist	Allen Duffy
	Project Manager	Charles Barrie

6.2. OPERATIONS REPORTING

The initial contract was signed on November 3, 2015 and was revised December 18, 2015 to accommodate increased survey coverage. On December 18, 2015 the aircraft and crew arrived at Farmington, MO and the following day the base station was setup and a successful cosmic calibration was performed. Poor weather prevented further calibrations and the crew departed for Christmas break on December 22nd. The crew returned on January 3, 2016 and was delayed by weather until January 5th to fly a successful Figure of Merit. Weather and GPS equipment malfunction further delayed the survey another 4 days.

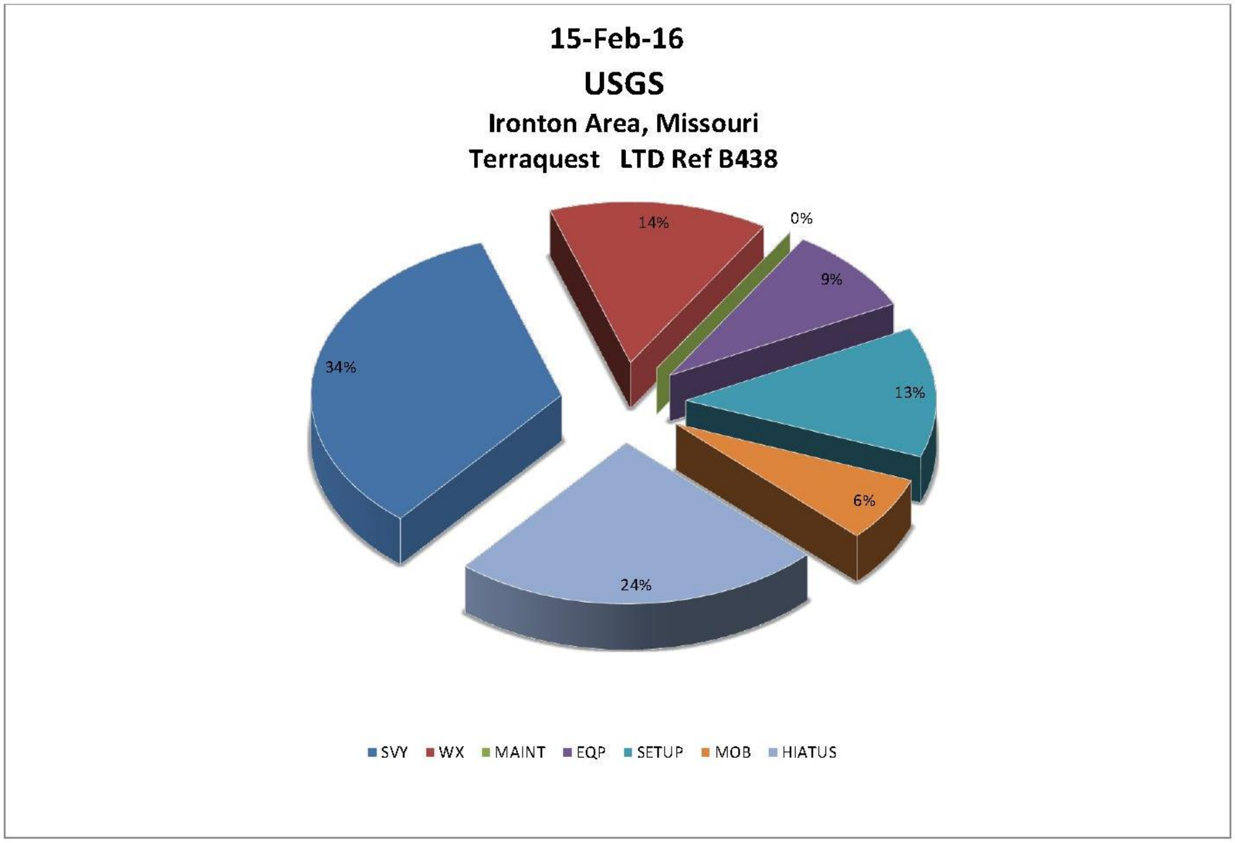
The Ironton survey was flown successfully in 26 flights, XKS512-538 over 26 days from January 10th to February 15th. Total rejected and reflown data was 275 kilometres. There were 15.5 survey days, 6.6 weather days and 4 equipment maintenance days. The crew was released to demobilize on February 16, 2016. A summary chart of operations followed by line listing is provided in Section 9.2 Appendix II.

At times the ground was slightly frozen at the surface and there was no significant accumulation of snow during any of the survey flights.

The pilot maintained personal and aircraft log books. The operator recorded all calibration and flight activity on a flight log which was sent to the survey geophysicist along with airborne and base station data. The geophysicist entered all daily activity into an Excel spread sheet. From this spreadsheet daily, weekly and summary reports were automatically generated. The Summary Report lists productions statistics for all flights each day and is shown in Appendix II. The geophysicist performed quality control on the raw survey data and forwarded the raw data to the client via the ftp site after each flight.

All survey personnel adopted and worked under the Terraquest Ltd. Health, Safety and Environmental Protection Manual (which include the Site Specific Safety Plan and the Emergency Response Plan), aviation Safety Management System (SMS), and guidelines from the IAGSA safety and security standards. All aircraft maintenance items were supervised by and signed out by an Approved Mechanical Engineer (AME) under Canadian Aviation Regulations (CARs) with signing authority through Leggat Aviation.

Cross border operations were under the Authority of NAFTA under Operations Specifications No.56 of the Terraquest Ltd. Transport Canada Air Operators Certificate number 6179 and FAA Certificate of Authorization for Specialty Air Services in the USA. For this specific survey, a Certificate of Waiver to permit low level geophysical survey flight as required by FAA Part 91.119(b) was obtained through the St. Louis MO Flight Standards District Office (FAA Form 7711-2).



6.3. BASE OF OPERATIONS

The base of operations including the magnetic base station was at Farmington, MO. The crew stayed at Holiday Inn Express. Internet access was satisfactory.

7. Data Processing

7.1. DATA QUALITY CONTROL

The field data were examined during the survey to inspect for quality control and tolerances on all channels. All data were checked for continuity and integrity. Note that GPS satellite based augmentation system correction was done in real-time during the survey using WAAS broadcast services. The magnetic data were real-time compensated during data acquisition using the fluxgate data.

7.2. PRE-PROCESSING OF POSITIONAL DATA (GPS)

The raw GPS data from the aircraft were recovered as binary files. The latitudes, longitudes and altitudes were in WGS84 spheroid and converted into UTM (metre) co-ordinates. A point to point speed calculation was then done from the final X, Y co-ordinates and reviewed as part of the quality control. The flight data were then cut back to the proper survey line limits and a preliminary plot of the actual flight path was done and compared to the planned flight path to verify the navigation.

7.3. DIGITAL TERRAIN MODEL (DTM)

The DTM was created by subtracting the radar altimeter from the GPS height followed by mild micro-level corrections limited to +/- 8 metres.

7.4. FINAL MAGNETIC DATA PROCESSING

1. Lag Correction of Total Magnetic Field

The Evaluation of the magnetic lag factor was accomplished by acquiring survey data flown in opposite directions over a cultural anomaly. The measured factor was 0.57 fiducials for the tail Magnetic sensor. (See Section 5.2)

2. Diurnal Data and diurnal correction of Total Magnetic Field

Magnetic data from the Diurnal Base Station were scrutinized for spurious readings (data spikes) and any obvious cultural interference. Any such features were manually removed and the data re-interpolated (Akima spline) to maintain a continuous record. Only the tie lines were diurnal corrected.

3. Heading correction of Total Magnetic Field

The magnetic heading effect was determined by flying a cloverleaf pattern at survey elevation, and oriented in the same directions as the survey lines and control lines. The data were subsequently used to correct measured airborne magnetic readings. (Section 5.3)

4. Total Magnetic Field Tie-Traverse Line Intersection Leveling

The heading and lag corrected data were further refined using tie-line levelling. Using the Geosoft Oasis implementation of this procedure, an initial table of tie-traverse line intersection differences is compiled (together with supporting ancillary parameters such as local gradient, etc.) and intersection data is loaded into the processing databases. In a series of iterative levelling passes, outlier intersection values are either disabled or modified to refine and finalize the overall result.

5. Total Magnetic Field Micro-levelling

Minor levelling imperfections may still exist in the intersection levelled data, most likely due to incomplete removal of diurnal influences in sections of lines between intersection points. These errors are removed by application of mild micro-levelling procedure whereby highly directional filtering identifies and removes residual noise correlated with the traverse direction. The resulting corrections are limited to the maximum amplitude of +/- 10 nT to avoid “damaging” valid, geologic responses.

The International Geomagnetic Reference Field (IGRF) was then calculated from the 2015 model year extrapolated to 31 January 2016 at the mean survey elevation of 458 metres above Geoid and removed from the corrected values to achieve the Anomalous Total Magnetic Intensity.

6. Calculated Vertical Derivative

The first Vertical Derivative was calculated using a 2D FFT operator on the Total Magnetic Intensity grid. Unwanted, high frequency “ ringing” in the resulting 1VD grid was minimized by concurrent application of an 8^{th} order Butterworth low pass filter keyed to the line spacing.

7. Measured Horizontal Gradients

Terraquest solves the spatial mathematical relationship of the three total fields measurements (left, right and tail) by using the accurate location of the three magnetic sensors in space to directly calculate the transverse and longitudinal gradients with respect to grid north at each point along the survey line.

Both gradients were then median-levelled to remove bias; there were no further corrections. Following this, the transverse and longitudinal gradients were gridded using the minimum curvature algorithm and a cell size of 50 metres. The measured transverse and longitudinal gradients provide an improved rendition of the shorter wavelengths in magnetic field than the residual magnetic field measured by the tail sensor alone. This is because the direction and amplitude of the field's total horizontal gradient can be determined using the 2 measured gradients, providing information regarding the behaviour of the magnetic field in-between traverse lines. Thus, it is useful to incorporate the gradient data in the preparation of the residual magnetic field grid. The resulting product is the gradient-enhanced residual magnetic field grid. The tie line levelled magnetic field data were used as the input to the gradient-enhanced gridding process.

8. Reconstructed Total Magnetic Field (RTF)

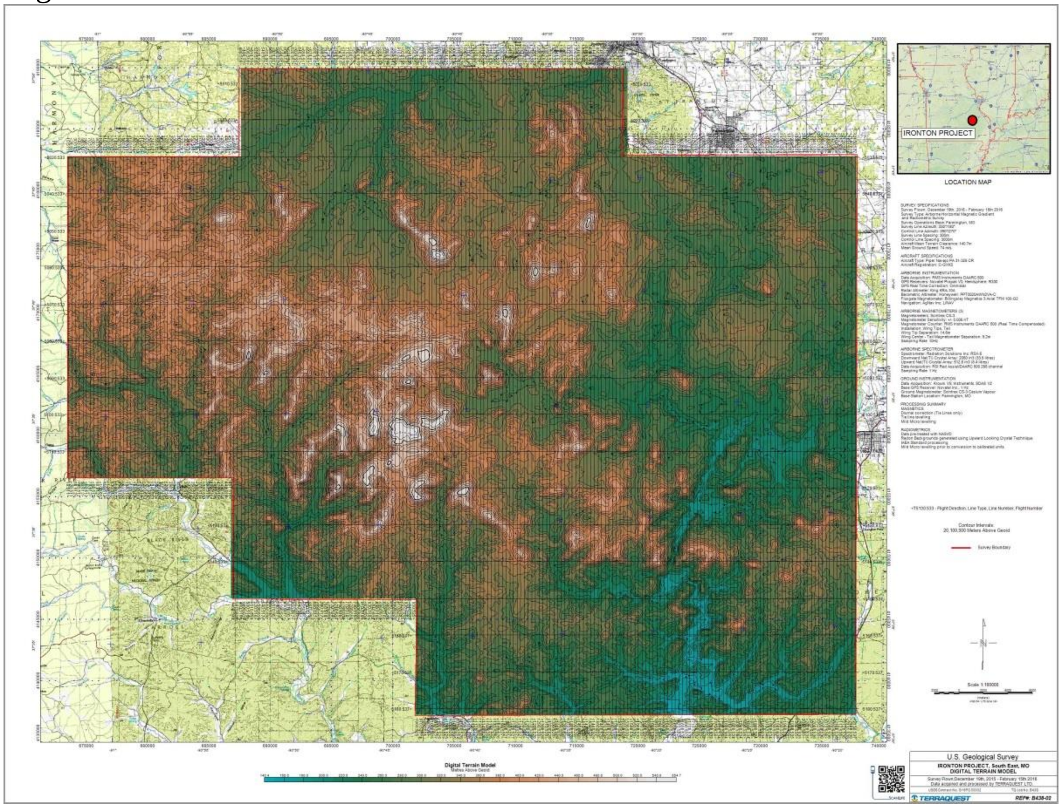
Data grids of the measured horizontal gradients (HX, HY) were used to generate the Reconstructed Total Magnetic Field using the 2D FFT process described by J. B. Nelson*. This product (RTF) has the advantage of being un-affected by magnetic diurnal activity, though longer magnetic spatial wavelengths are not represented due to measurement resolution limitations in the magnetometers. The resulting data units (expressed as pseudo nanoTesla) are not true nT: approximate conversion to true nT may be accomplished by application of scaling factor if required. Using the calculated Reconstructed Total Field data grid, a "RTF" Geosoft database channel is created by performing a grid look-up ("grid sample") for each data point in the production database. Only grids were produced for the Total Reconstructed Field.

(reference: Nelson, J.B., 1994, Leveling total-field aeromagnetic data with measured horizontal gradients: Geophysics, 59, 1166-1170).

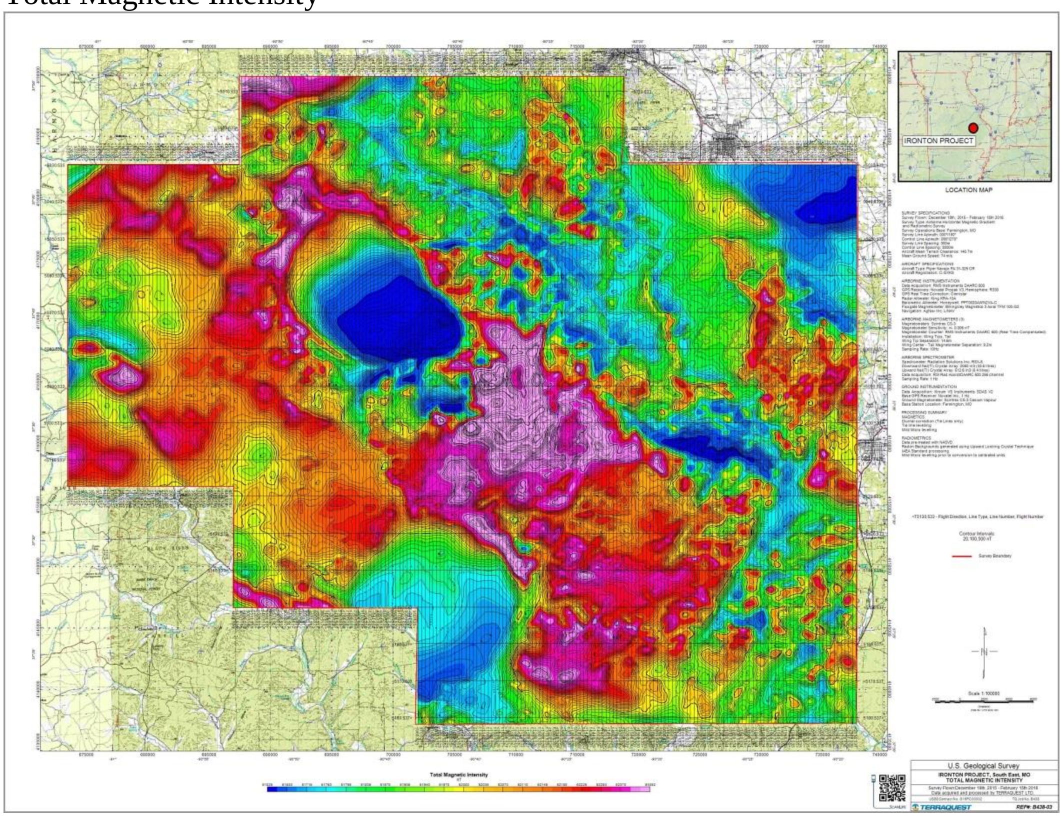
9. Data Grids

Magnetic data grids were created using bidirectional Akima spline data interpolations at a cell size of 50 metres.

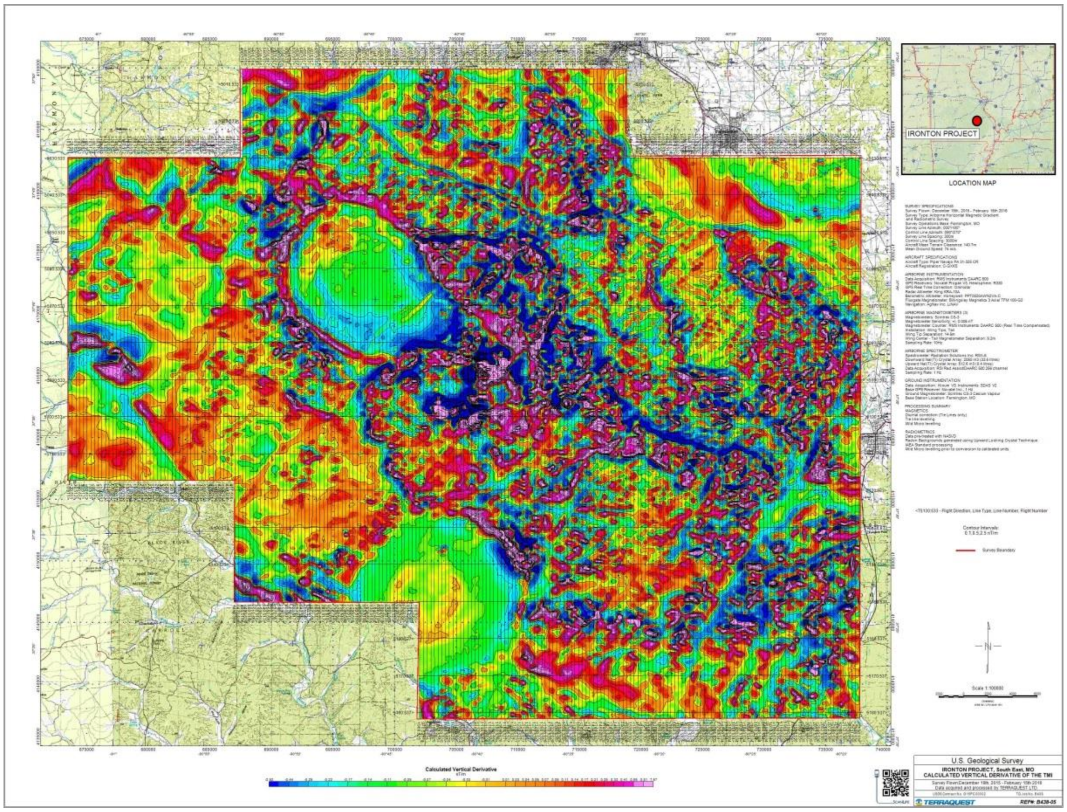
Digital Terrain Model



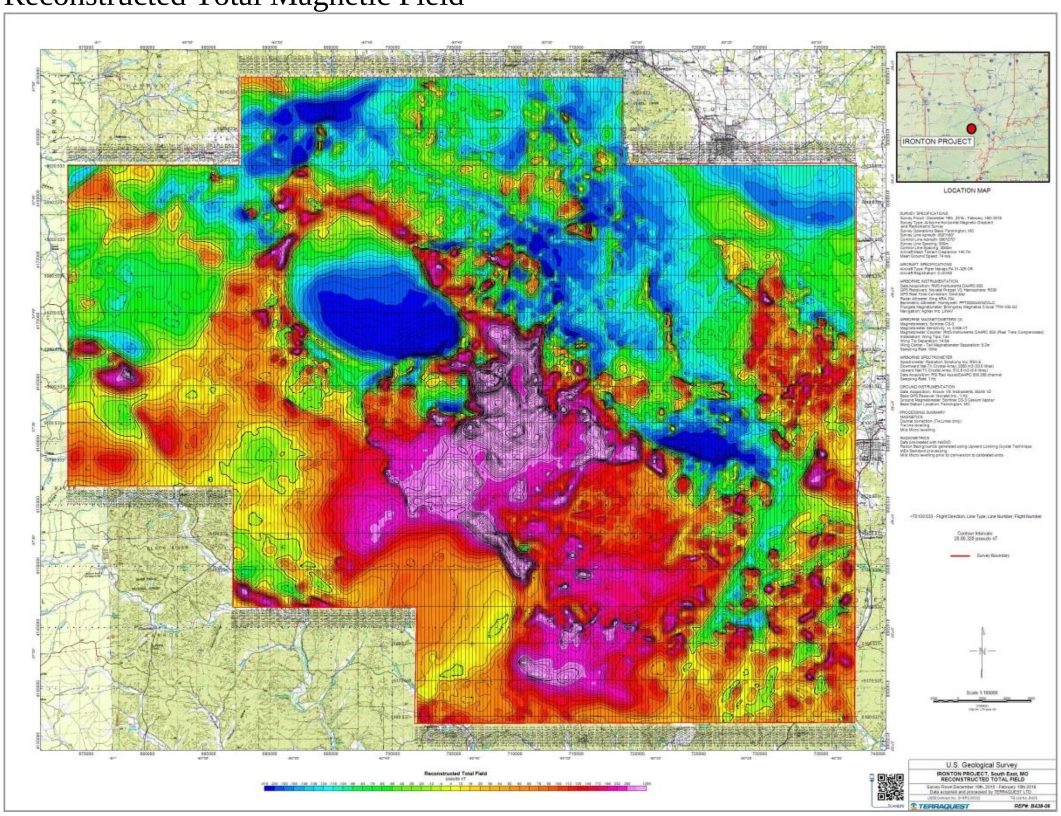
Total Magnetic Intensity



Calculated Vertical Derivative of the TMI



Reconstructed Total Magnetic Field



7.5. FINAL RADIOMETRIC DATA PROCESSING

The radiometric data were processed according to guidelines established in the definitive IAEA Technical Report "Airborne Gamma Ray Spectrometer Surveying" (IAEA Technical Reports Series No. 323, 1991). A detailed description of the various correction steps may be found in ***9.5 Appendix V – Detailed Radiometric Processing Notes***; however, the following is a brief, generalized description of the data reduction process:

1. Energy Windows

Recorded as a 256 channel spectrum, the four raw integral (or "terrestrial") windows (Total Count, Potassium, Uranium and Thorium) were initially generated by summing the recorded counts between their appropriate channel limits – as specified below:

Window("ROI")	Energy Range (keV)		Channel Range	
Total Count	410	2810	034	234
Potassium	1370	1570	114	131
Uranium	1660	1860	138	155
Thorium	2410	2810	201	234
Cosmic	3000	∞	255	
(Overall channel number range is indexed 0 - 255)				

2. NASVD Noise Reduction

An effective way of ameliorating any effects of decreased signal-to-noise ratio is to reduce the natural Poisson noise component by application of modern principal component analysis techniques - NASVD (or "Noise Adjustment by Singular Value Decomposition" *) being a particularly effective technique. In this process, the measured 256 channel gamma ray spectra are analyzed en masse, producing a set of 256 distinct "principal components" which can be recombined to produce very accurate representations of the original spectral measurements. Given consistent recording of the gamma-ray spectra, the actual "signal" part is concentrated in the first few principal components with the remaining higher order components largely concerned with noise. By reconstructing the original spectra using only these initial components (for example, in this project components 0 - 4 were used in the spectral reconstruction), statistical measurement noise is largely suppressed. ROIs (Total Count, Potassium, Uranium and Thorium) are then extracted from the noise reduced spectra.

** Hovgaard, J.; Grasty, R.L. : Reducing Statistical Noise in Airborne Gamma Ray Data Through Spectral Component Analysis – presented at Exploration97, Toronto, Canada 1997(Paper 98 - Radiometric Methods and Remote Sensing)*

Recognizing that the NASVD enhance data reduction process uses modeled - as opposed to measured - spectra as its starting point, radiometric data were delivered as two separate data streams: one traditionally processed (non-enhanced) and the other NASVD enhanced. Noise levels are clearly reduced in the NASVD enhanced data.

3. Aircraft and Cosmic Background Correction

The Cosmic and fixed aircraft components of the overall background level of radiation may be calculated using coefficients determined during a specific calibration procedure (see ***9.6 Appendix VI – Cosmic Calibration***). In this correction step, the assumed linear relationship between count rates measured in the high energy Cosmic window (> 3.0 MeV) and the Cosmic and Aircraft (fixed) contributions to the individual backgrounds in the four terrestrial windows (Total Count, Potassium, Uranium and Thorium) is exploited. Remaining background levels in the resulting corrected count rates will only be influenced by the variable, atmospheric Radon component.

4. Atmospheric Background Correction

A background component, primarily due airborne Radon daughter products, can remain in each of the radioelement windows. The level of background radiation is expected to vary temporally and geographically since the distribution of airborne sources depends on a host of factors such as atmospheric conditions, local ground conditions, etc.

Residual background levels of radiation were determined from data acquired on daily background test lines (flown at 1800 feet where geologic signal contributions are negligible). The data was corrected for Cosmic and Aircraft sources to estimate the remaining atmospheric radiation component.

5. Compton Stripping

Following background correction, the measured levels in the three terrestrial spectral windows – Potassium, Uranium and Thorium - are corrected for the natural process of Compton Scattering, by which energy deriving from higher energy sources are down-scattered into lower energy classifications. This procedure, described in greater detail in ***9.5 Appendix V – Detailed Radiometric Processing Notes***, results in count rates classified as purely Potassium, Uranium and Thorium without influence from the higher energy sources of radiation (this correction step primarily affects the two lower energy spectral windows: Uranium and Potassium).

6. Altitude Attenuation Correction

Effects due to varying terrain clearance are compensated for in this correction step. By applying experimentally determined Altitude Attenuation coefficients keyed to terrain clearance corrected to Standard Temperature and Pressure, measured count rates are adjusted to a constant terrain clearance (normally the survey's programmed clearance of 100 metres). Refer to ***9.8 Appendix VIII – Altitude Attenuation*** for details on the determination of the exponential altitude attenuation coefficients.

7. Microlevelling

Prior to conversion to calibrated units the data were treated with mild microlevellng with limits as follows: total count +/- 45, Potassium +/- 5.5, Uranium +/- 2 and Th +/- 1.1.

8. Conversion to Ground Units

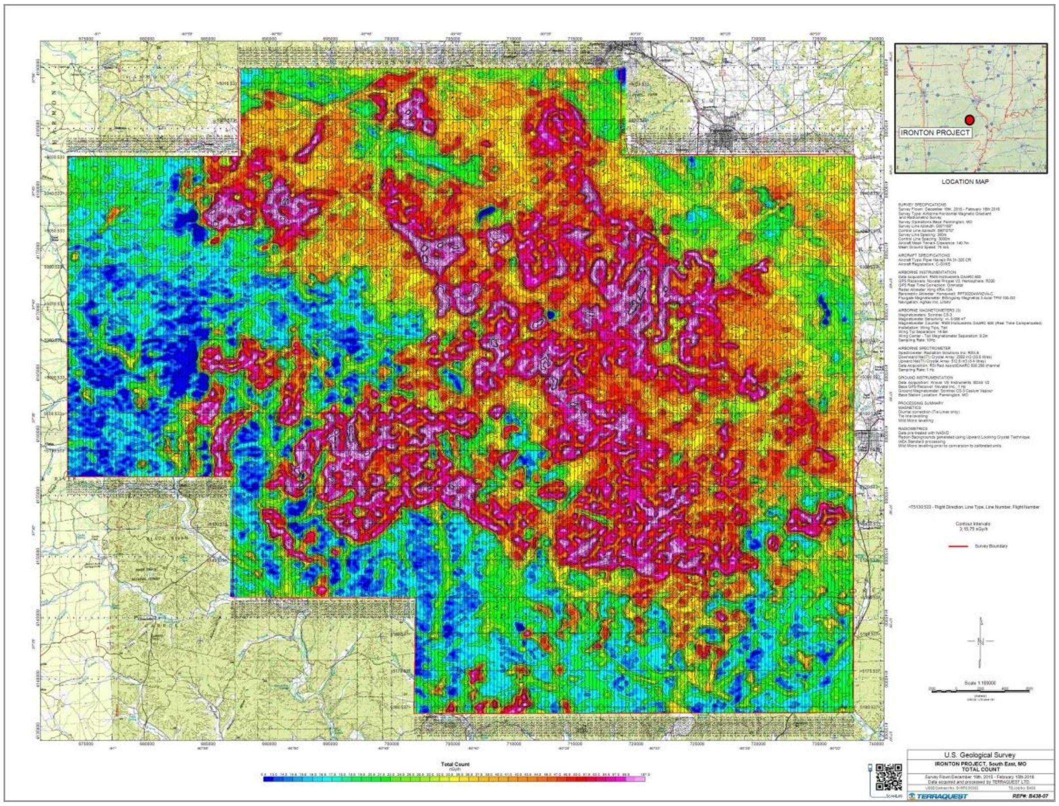
As a final step, the count rates in the integral channel window (Total Count) and the three spectral channel windows (Potassium, Uranium and Thorium) are converted to equivalent ground concentration units through application of sensitivity factors developed during a calibration flight over an approved radiometric test range. The system was calibrated at the Geologic Survey of Canada's calibration facility located outside Ottawa, Ontario, Canada. See ***9.9 Appendix IX – Sensitivity Factors***. Conversion of measured count rates to ground units has the advantage of presenting the measured levels of radiation using a standardized physical reference framework as well as to facilitate integration of the data with other radiometric data sets. A tabular summary of presentation units follows:

Window ("ROI")	Description	Unit
Total Count	Dosage Rate	nGy/hr
Potassium	Concentration	%K
Uranium	Equivalent Concentration	ppm eU
Thorium	Equivalent Concentration	ppm eTH

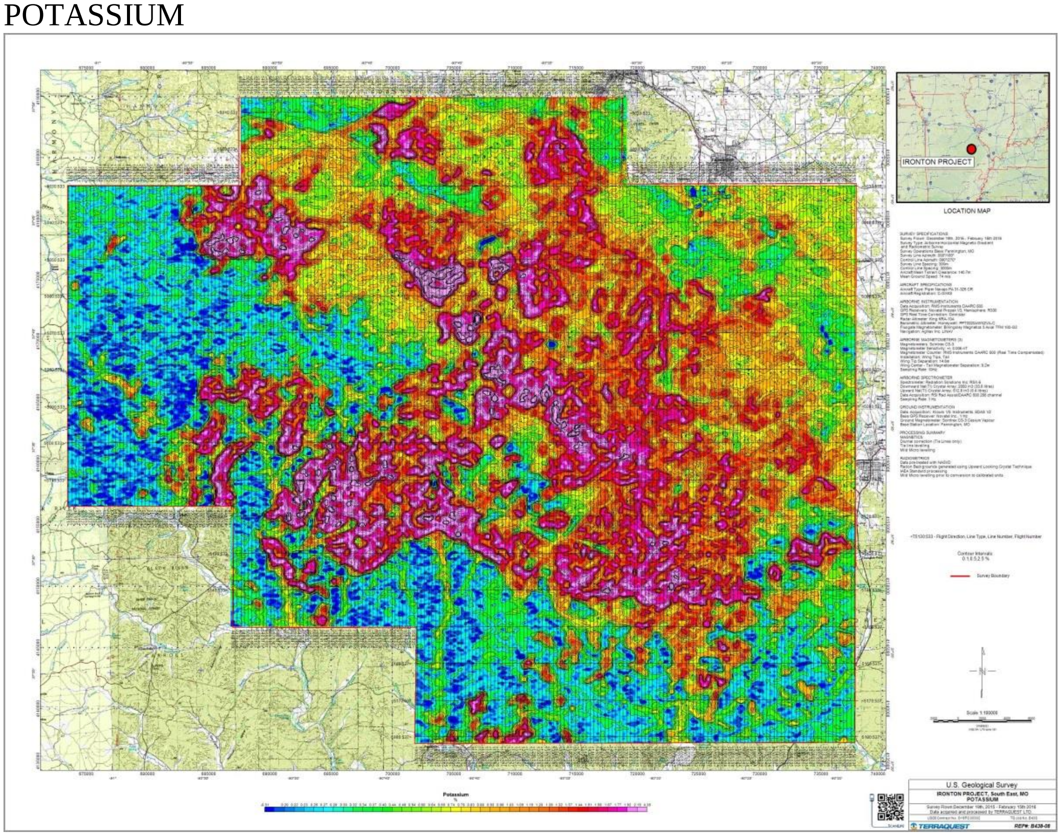
9. Gridding

Final data grids were constructed using a symmetrical grid cell definition of 60 x 60 metres. The grid was generated using Minimum Curvature interpolation. The coordinate projection for the grids was WGS84 UTM Zone 15N.

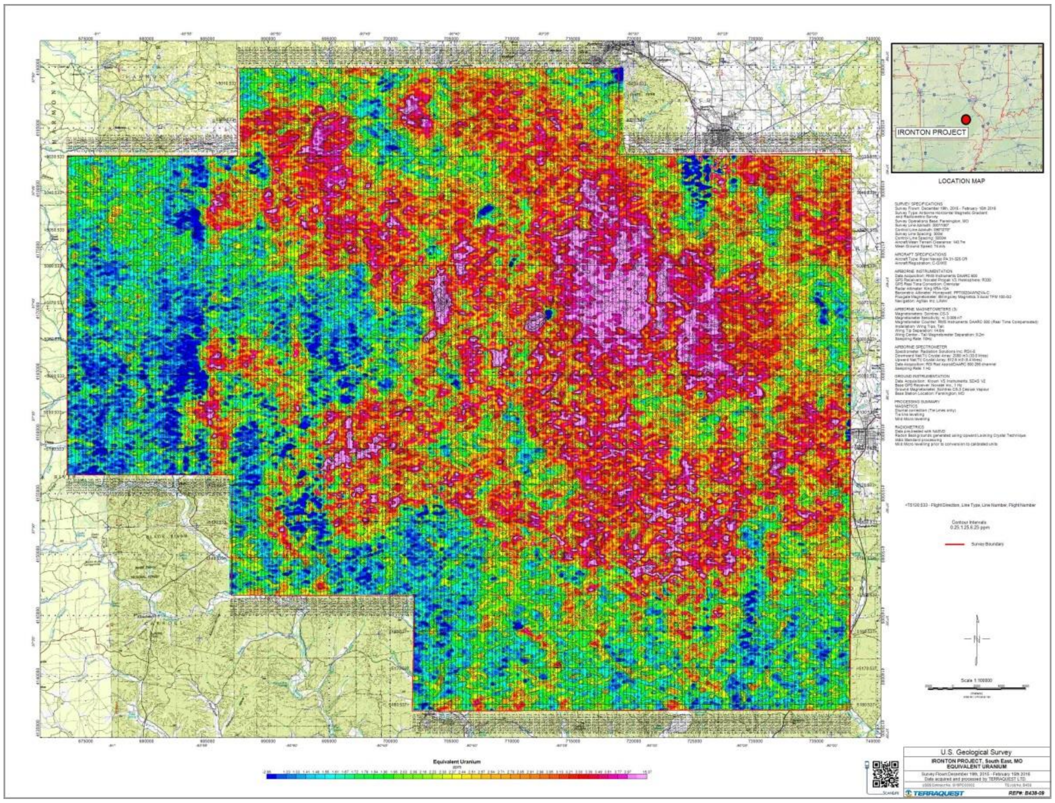
TOTAL COUNT



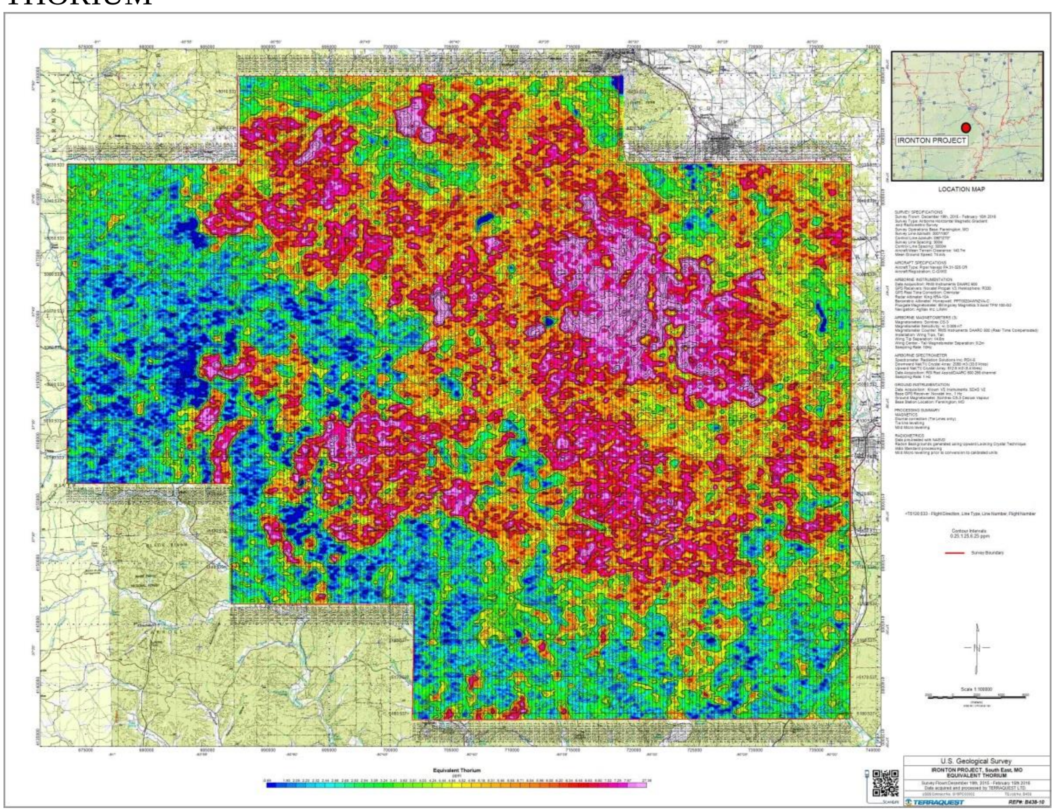
POTASSIUM



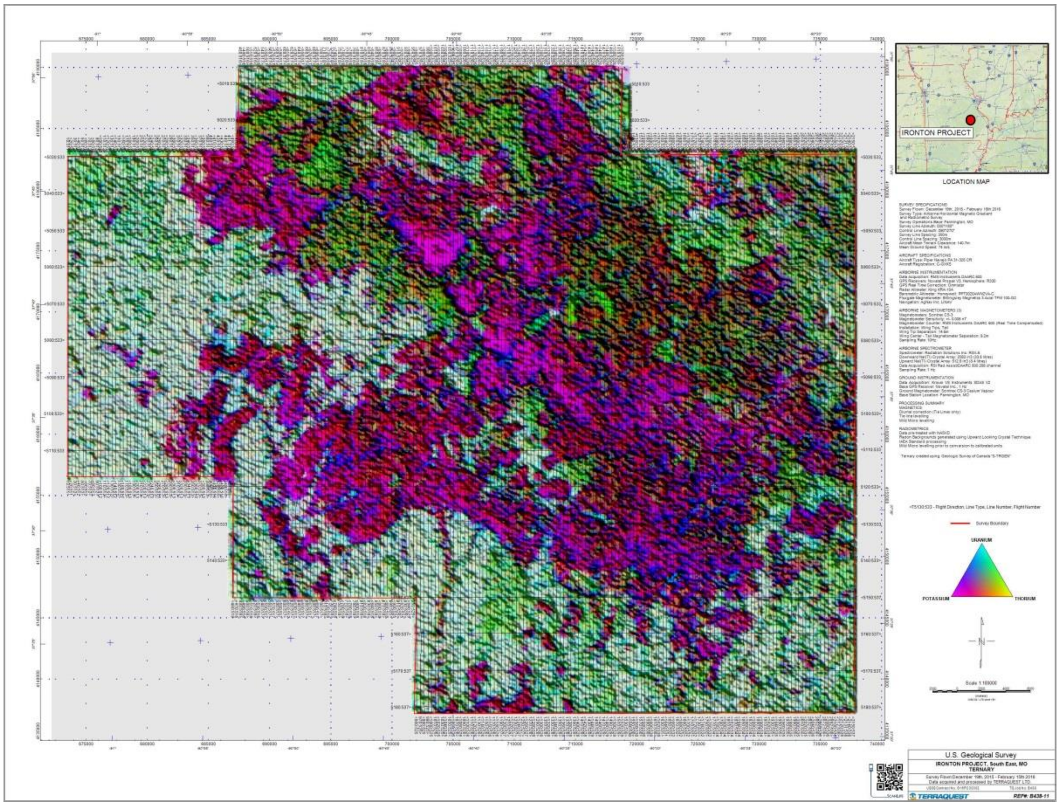
URANIUM



THORIUM



TERNARY


IRONTON PROJECT
LOCATION MAP
Survey Boundary
URANIUM
POTASSIUM
THORIUM
U.S. Geological Survey
IRONTON PROJECT, South East, MO
TERNARY
Data acquired and processed by TERRAQUEST LTD.
TERRAQUEST
REF#: B438-11

7.6. LIST OF FINAL PRODUCTS

A complete list of all final products is listed in the ReadMe file Appendix 9.10. All products including this Report are contained on an Archive DVD in the back pocket of the Report.

The following maps were produced in digital format for the survey:

1. Flight Path
2. Digital Terrain Model (m)
3. Total Magnetic Intensity (TMI) (nT)
4. Anomalous Magnetic Field
5. Calculated Vertical Gradient of TMI (nT/m)
6. Reconstructed Total Magnetic Field (RTF) (pseudo nT)
7. Total Count (nGy/hr)
8. Potassium (%)
9. Thorium (eTh ppm)
10. Uranium (eU ppm)
11. Ternary

The following digital products were produced:

- Databases in GEOSOFT GDB (compatible with 4.1 or higher; Magnetic data and Radiometric data are in separate databases)
- Digital grid archives in GEOSOFT GRD format
- GEOSOFT MAP files used to generate the above listed final maps
- Map Images in high resolution JPEG format
- Operations Report in PDF format

8. SUMMARY

An airborne high sensitivity, Horizontal Magnetic Gradient and Radiometric survey was performed for the U.S. Geological Survey over the Ironton Project in southeastern Missouri. It was flown with a preplanned controlled drape mode based on 100 metres above the highest obstacle, and with an average flown elevation of 140.7 metres above the ground. The survey parameters were 300 metre line intervals, 3,000 metre tie line intervals and data sample point density along the flight lines of approximately 74 metres for 1Hz data (radiometric) and 7.4 metres for the 10Hz data (magnetic and GPS data). The base of operations including magnetic base station was at Farmington Regional Airport, MO.

The data were subjected to final processing to produce the following grids and digital map files:

a) **Magnetics**: total magnetic intensity (TMI) and Anomalous TMI
b) **Gradient Magnetics:** calculated first vertical derivative of TMI; Reconstructed Total Magnetic Field
c) **Radiometric**: Total Count, Potassium, Uranium, Thorium and Ternary Plot

This report and all digital products including a ReadMe file have been archived on a DVD. The databases are in ASCII (XYZ) and Geosoft (GDB) formats (including raw data), and the grid and map files are also in Geosoft format (.grd, .map). High resolution jpeg images of the maps are also included.

Respectfully Submitted,

Charles Barrie, M.Sc., P.Geo.
Vice President
Terraquest Ltd.

9. APPENDICES

9.1. APPENDIX I - CERTIFICATE OF QUALIFICATION

I, Charles Barrie, certify that I:

1) am registered as a Fellow with the Geological Association of Canada, as a P.Geo. with the Association of Professional Geoscientists of Ontario (APGO) and work professionally as a geologist,
2) hold an Honours degree in Geology from McMaster University, Canada, obtained in 1977,
3) hold an M.Sc. in Geology from Dalhousie University, Canada, obtained in 1980,
4) am a member of the Prospectors and Developers Association of Canada,
5) am a member of the Canadian Institute of Mining, Metallurgy and Petroleum,
6) have worked as a geologist for over thirty years,
7) am employed by and am an owner of Terraquest Ltd., specializing in high sensitivity airborne geophysical surveys, and
8) have prepared this operations and specifications report pertaining to airborne data collected by Terraquest Ltd..

Markham, Ontario, Canada Signed

Charles Barrie, M.Sc., P.Geo.
Vice President
Terraquest Ltd.

PROFESSIONAL GEOSCIENTIST
CHARLES Q. BARRIE
PRACTISING MEMBER
1874
ONTARIO

9.2. APPENDIX II – FIELD REPORT SUMMARY

TERRAQUEST LTD. Daily Operations Field Report Summary

Job #	B438	USGS										Name:		Ironton				Main Base of Operations:			Farmington, Mo		
REPORT NUMBER	DATE	Location	Activity	Flight Numbers			Flight Hours		Survey Hours		Production Kilometers				%Complete	Day Classification							
							Day	Total	Day	Total	Day	Total	Reflight Day	Reflight Total		Survey	Weather	Maintenance	Equipment	Setup and Calibrations	Mobilization	Hiatus	Total
REP001	15-Dec-15	MOB - In Transit	MOB	XKS498			0:30:00	0:30:00													1.0		1.0
REP002	16-Dec-15	MOB - In Transit	WX					0:30:00									1.0				1.0		2.0
REP003	17-Dec-15	MOB - In Transit	MOB	XKS499	XKS500	XKS501	4:10:00	4:40:00									1.0				2.0		3.0
REP004	18-Dec-15	Farmington, Mo	MOB	XKS502	XKS503		1:15:00	5:55:00									1.0				3.0		4.0
REP005	19-Dec-15	Farmington, Mo	SETUP	XKS504			2:54:00	8:49:00									1.0			1.0	3.0		5.0
REP006	20-Dec-15	Farmington, Mo	SETUP	XKS505			2:17:00	11:06:00									1.0			2.0	3.0		6.0
REP007	21-Dec-15	Farmington, Mo	WX					11:06:00									2.0			2.0	3.0		7.0
REP008	22-Dec-15	Farmington, Mo	SETUP	XKS506			1:20:00	12:26:00									2.0			3.0	3.0		8.0
REP009	03-Jan-16	Farmington, Mo	SETUP					12:26:00									2.0			4.0	3.0	11.0	20.0
REP010	04-Jan-16	Farmington, Mo	WX					12:26:00									3.0			4.0	3.0	11.0	21.0
REP011	05-Jan-16	Farmington, Mo	SETUP	XKS507			2:03:00	14:29:00									3.0			5.0	3.0	11.0	22.0
REP012	06-Jan-16	Farmington, Mo	PERMIT					14:29:00									3.0			6.0	3.0	11.0	23.0
REP013	07-Jan-16	Farmington, Mo	EQP/GPS	XKS508	XKS509		0:36:00	15:05:00									3.0		1.0	6.0	3.0	11.0	24.0
REP014	08-Jan-16	Farmington, Mo	EQP/GPS	XKS510			0:24:00	15:29:00									3.0		2.0	6.0	3.0	11.0	25.0
REP015	09-Jan-16	Farmington, Mo	WX					15:29:00									4.0		2.0	6.0	3.0	11.0	26.0
REP016	10-Jan-16	Farmington, Mo	SVY	XKS511	XKS512		3:17:00	18:46:00	2:07:01	2:07:01	425.95	425.95			4.15%	1.0	4.0		2.0	6.0	3.0	11.0	27.0
REP017	11-Jan-16	Farmington, Mo	SVY	XKS513			3:58:00	22:44:00	3:13:17	5:20:17	612.30	1038.25			10.13%	2.0	4.0		2.0	6.0	3.0	11.0	28.0
REP018	12-Jan-16	Farmington, Mo	EQP	XKS514			0:31:00	23:15:00		5:20:17		1038.25			10.13%	2.0	4.0		3.0	6.0	3.0	11.0	29.0
REP019	13-Jan-16	Farmington, Mo	EQP	XKS515			0:20:00	23:35:00		5:20:17		1038.25			10.13%	2.0	4.0		4.0	6.0	3.0	11.0	30.0
REP020	14-Jan-16	Farmington, Mo	SVY	XKS516			3:04:59	26:39:59	2:30:49	7:51:06	494.35	1532.60			14.95%	3.0	4.0		4.0	6.0	3.0	11.0	31.0
REP021	15-Jan-16	Farmington, Mo	SVY	XKS517			3:59:00	30:38:59	3:28:12	11:19:18	741.70	2274.30			22.18%	4.0	4.0		4.0	6.0	3.0	11.0	32.0
REP022	16-Jan-16	Farmington, Mo	SVY	XKS518			3:55:00	34:33:59	3:29:49	14:49:08	785.33	3059.63			29.84%	5.0	4.0		4.0	6.0	3.0	11.0	33.0
REP023	03-Feb-16	Farmington, Mo	SVY	XKS525			4:14:00	38:47:59	3:50:14	18:39:21	889.97	3949.60			38.52%	6.0	4.0		4.0	6.0	3.0	11.0	34.0
REP024	04-Feb-16	Farmington, Mo	SVY	XKS526			3:02:00	41:49:59	2:38:58	21:18:19	637.71	4587.31			44.74%	7.0	4.0		4.0	6.0	3.0	11.0	35.0
REP025	05-Feb-16	Farmington, Mo	SVY	XKS527			2:07:00	43:56:59	1:45:12	23:03:31	425.14	5012.45			48.89%	8.0	4.0		4.0	6.0	3.0	11.0	36.0
REP026	06-Feb-16	Farmington, Mo	SVY	XKS528	XKS529		6:36:00	50:32:59	5:32:52	28:36:23	1381.70	6394.15			62.36%	9.0	4.0		4.0	6.0	3.0	11.0	37.0
REP027	07-Feb-16	Farmington, Mo	SVY	XKS530			2:26:00	52:58:59	2:02:51	30:39:14	459.37	6853.52			66.84%	10.0	4.0		4.0	6.0	3.0	11.0	38.0
REP028	08-Feb-16	Farmington, Mo	WX					52:58:59		30:39:14		6853.52			66.84%	10.0	5.0		4.0	6.0	3.0	11.0	39.0
REP029	09-Feb-16	Farmington, Mo	WX/SVY	XKS531			0:43:00	53:41:59	0:26:31	31:05:46	91.87	6945.40			67.74%	10.5	5.5		4.0	6.0	3.0	11.0	40.0
REP030	10-Feb-16	Farmington, Mo	SVY	XKS532			2:52:00	56:33:59	2:28:24	33:34:10	551.24	7496.64			73.12%	11.5	5.5		4.0	6.0	3.0	11.0	41.0
REP031	11-Feb-16	Farmington, Mo	SVY	XKS533			3:47:00	60:20:59	3:27:38	37:01:48	803.39	8300.03			80.95%	12.5	5.5		4.0	6.0	3.0	11.0	42.0
REP032	12-Feb-16	Farmington, Mo	SVY	XKS534	XKS535		6:22:00	66:42:59	5:26:09	42:27:56	1194.36	9494.38			92.60%	13.5	5.5		4.0	6.0	3.0	11.0	43.0
REP033	13-Feb-16	Farmington, Mo	SVY	XKS536	XKS537		4:37:00	71:19:59	3:27:05	45:55:01	758.72	10253.10			100.00%	14.5	5.5		4.0	6.0	3.0	11.0	44.0
REP034	14-Feb-16	Farmington, Mo	WX					71:19:59		45:55:01		10253.10			100.00%	14.5	6.5		4.0	6.0	3.0	11.0	45.0
REP035	15-Feb-16	Farmington, Mo	SVY	XKS538			2:33:00	73:52:59	2:12:32	48:07:33		10253.10	275.62	275.62	100.00%	15.5	6.5		4.0	6.0	3.0	11.0	46.0

Line Listing

TERRAQUEST JOB LOG - B346/Quetico - MAG-RAD-(XDS/VLF)- C-GXKS 13/04/2016

TERRAQUEST LIMITED

JOB "BIBLE" : C-GXKS

TERRAQUEST PROJECT REFERENCE : B438

CLIENT	USGS					
BASE	Farmington, Missouri		PROJECT	IRONTON		
FIELD OPS START :	15-Dec-15	END :	13-Feb-16	TOTAL DAYS:	50	11 : Total Day Adj Factor
				LKMS/DAY:	205.1	

TERRAQUEST CREW		
	Project Manager (Terraquest)	Charles Barrie (Office)
	Project Geophysicist	Allen Duffy (Office)
	Pilot	Rck Smith
	Pilot	Serguey Salnicov
	Operator	

OVERALL PROJECT SUMMARY

Note: minimum chargeable line length: kms

	NUMBER	KMS	TOTAL FLOWN	TOTAL REMAINING	% COMPLETION	REFLIGHT KMS
TOTAL LINES	233	10253.1	10253.1		100.00%	275.6
TRAVERSE	215	9288.2	9288.2		100.00%	
TIE	18	964.9	933.0	31.9	96.69%	
SPECIAL						
		PROD #	PROD KMS	RFLT KMS		
TOTAL KMS FOR FLIGHT	XKS538			275.6		

SURVEY BLOCK SUMMARY

Type codes:		BLOCK		PLANNED LINES	PLANNED KMS	TOTAL FLOWN	TOTAL REMAINING	%COMPLETION	REFLIGHT KMS	Comments Codes and Abbreviations:
Trav	Tie	Ironton Area, Missouri	IRO	233	10253.1	10253.1		100.00%	275.6	DIU: Magnetic Diurnal
TravSplit	TieSplit	(Rev 18 DEC 2015)								
RefTrav	RefTie									

IRONTON AREA, MISSOURI

LINE	BLK	TYPE	KMS (FLIGHT PLAN)	DATE FLOWN	FLIGHT	KMS FLOWN	REFLIGHT	KMS	COMMENTS
10	IRO	TRAV	26.6	10-Jan-16	XKS511	26.6			
20	IRO	TRAV	26.6	10-Jan-16	XKS511	26.6			
30	IRO	TRAV	26.6	10-Jan-16	XKS512	26.6			
40	IRO	TRAV	26.6	10-Jan-16	XKS512	26.6			
50	IRO	TRAV	26.6	10-Jan-16	XKS512	26.6			
60	IRO	TRAV	26.6	10-Jan-16	XKS512	26.6			
70	IRO	TRAV	26.6	10-Jan-16	XKS512	26.6			
80	IRO	TRAV	26.6	10-Jan-16	XKS512	26.6			
90	IRO	TRAV	26.6	10-Jan-16	XKS512	26.6			
100	IRO	TRAV	26.6	10-Jan-16	XKS512	26.6			
110	IRO	TRAV	26.6	10-Jan-16	XKS512	26.6			
120	IRO	TRAV	26.6	10-Jan-16	XKS512	26.6			
130	IRO	TRAV	26.6	10-Jan-16	XKS512	26.6			
140	IRO	TRAV	26.6	10-Jan-16	XKS512	26.6			
150	IRO	TRAV	26.6	10-Jan-16	XKS512	26.6			
160	IRO	TRAV	26.6	10-Jan-16	XKS512	26.6			
170	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
180	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
190	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
200	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
210	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
220	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
230	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
240	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
250	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
260	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
270	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
280	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
290	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
300	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
310	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
320	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
330	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
340	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
350	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
360	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
370	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
380	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
390	IRO	TRAV	26.6	11-Jan-16	XKS513	26.6			
400	IRO	TRAV	26.6	14-Jan-16	XKS516	26.6			
410	IRO	TRAV	26.6	14-Jan-16	XKS516	26.6			

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TERRAQUEST JOB LOG - B346/Quetico - MAG-RAD-(XDS/VLF)- C-GXKS 13/04/2016

LINE	BLK	TYPE	KMS (FLIGHT PLAN)	DATE FLOWN	FLIGHT	KMS FLOWN	REFLIGHT	KMS	COMMENTS
420	IRO	TRAV	26.6	14-Jan-16	XKS516	26.6			
430	IRO	TRAV	26.6	14-Jan-16	XKS516	26.6			
440	IRO	TRAV	26.6	14-Jan-16	XKS516	26.6			
450	IRO	TRAV	26.6	14-Jan-16	XKS516	26.6			
460	IRO	TRAV	36.4	14-Jan-16	XKS516	36.4			
470	IRO	TRAV	36.4	14-Jan-16	XKS516	36.4			
480	IRO	TRAV	43.6	14-Jan-16	XKS516	43.6			
490	IRO	TRAV	43.6	14-Jan-16	XKS516	43.6			
500	IRO	TRAV	43.6	14-Jan-16	XKS516	43.6			
510	IRO	TRAV	43.6	14-Jan-16	XKS516	43.6			
520	IRO	TRAV	43.6	14-Jan-16	XKS516	43.6			
530	IRO	TRAV	43.6	14-Jan-16	XKS516	43.6			
540	IRO	TRAV	43.6	15-Jan-16	XKS517	43.6			
550	IRO	TRAV	43.6	15-Jan-16	XKS517	43.6			
560	IRO	TRAV	43.6	15-Jan-16	XKS517	43.6			
570	IRO	TRAV	43.6	15-Jan-16	XKS517	43.6			
580	IRO	TRAV	43.6	15-Jan-16	XKS517	43.6			
590	IRO	TRAV	43.6	15-Jan-16	XKS517	43.6			
600	IRO	TRAV	43.6	15-Jan-16	XKS517	43.6			
610	IRO	TRAV	43.6	15-Jan-16	XKS517	43.6			
620	IRO	TRAV	43.6	15-Jan-16	XKS517	43.6			
630	IRO	TRAV	43.6	15-Jan-16	XKS517	43.6			
640	IRO	TRAV	43.6	15-Jan-16	XKS517	43.6			
650	IRO	TRAV	43.6	15-Jan-16	XKS517	43.6			
660	IRO	TRAV	43.6	15-Jan-16	XKS517	43.6			
670	IRO	TRAV	43.6	15-Jan-16	XKS517	43.6			
680	IRO	TRAV	43.6	15-Jan-16	XKS517	43.6			
690	IRO	TRAV	43.6	15-Jan-16	XKS517	43.6			
700	IRO	TRAV	43.6	15-Jan-16	XKS517	43.6			
710	IRO	TRAV	43.6	16-Jan-16	XKS518	43.6			
720	IRO	TRAV	43.6	16-Jan-16	XKS518	43.6			
730	IRO	TRAV	43.6	16-Jan-16	XKS518	43.6			
740	IRO	TRAV	43.6	16-Jan-16	XKS518	43.6			
750	IRO	TRAV	43.6	16-Jan-16	XKS518	43.6			
760	IRO	TRAV	43.6	16-Jan-16	XKS518	43.6			
770	IRO	TRAV	43.6	16-Jan-16	XKS518	43.6			
780	IRO	TRAV	43.6	16-Jan-16	XKS518	43.6			
790	IRO	TRAV	43.6	16-Jan-16	XKS518	43.6			
800	IRO	TRAV	43.6	16-Jan-16	XKS518	43.6			
810	IRO	TRAV	43.6	16-Jan-16	XKS518	43.6			
820	IRO	TRAV	43.6	16-Jan-16	XKS518	43.6			
830	IRO	TRAV	43.6	16-Jan-16	XKS518	43.6			
840	IRO	TRAV	43.6	16-Jan-16	XKS518	43.6			
850	IRO	TRAV	43.6	16-Jan-16	XKS518	43.6			
860	IRO	TRAV	43.6	16-Jan-16	XKS518	43.6			
870	IRO	TRAV	43.6	16-Jan-16	XKS518	43.6			
880	IRO	TRAV	43.6	16-Jan-16	XKS518	43.6			
890	IRO	TRAV	43.6	03-Feb-16	XKS525	43.6			
900	IRO	TRAV	43.6	03-Feb-16	XKS525	43.6			
910	IRO	TRAV	43.6	03-Feb-16	XKS525	43.6			
920	IRO	TRAV	43.6	03-Feb-16	XKS525	43.6			
930	IRO	TRAV	43.6	03-Feb-16	XKS525	43.6			
940	IRO	TRAV	43.6	03-Feb-16	XKS525	43.6			
950	IRO	TRAV	43.6	03-Feb-16	XKS525	43.6			
960	IRO	TRAV	53.1	03-Feb-16	XKS525	53.1			
970	IRO	TRAV	53.1	03-Feb-16	XKS525	53.1			
980	IRO	TRAV	53.1	03-Feb-16	XKS525	53.1			
990	IRO	TRAV	53.1	03-Feb-16	XKS525	53.1			
1000	IRO	TRAV	53.1	03-Feb-16	XKS525	53.1			
1010	IRO	TRAV	53.1	03-Feb-16	XKS525	53.1			
1020	IRO	TRAV	53.1	03-Feb-16	XKS525	53.1			
1030	IRO	TRAV	53.1	03-Feb-16	XKS525	53.1			
1040	IRO	TRAV	53.1	03-Feb-16	XKS525	53.1			
1050	IRO	TRAV	53.1	03-Feb-16	XKS525	53.1			
1060	IRO	TRAV	53.1	03-Feb-16	XKS525	53.1			
1070	IRO	TRAV	53.1	04-Feb-16	XKS526	53.1			
1080	IRO	TRAV	53.1	04-Feb-16	XKS526	53.1			
1090	IRO	TRAV	53.1	04-Feb-16	XKS526	53.1			
1100	IRO	TRAV	53.1	04-Feb-16	XKS526	53.1			
1110	IRO	TRAV	53.1	04-Feb-16	XKS526	53.1			
1120	IRO	TRAV	53.1	04-Feb-16	XKS526	53.1			
1130	IRO	TRAV	53.1	04-Feb-16	XKS526	53.1			
1140	IRO	TRAV	53.1	04-Feb-16	XKS526	53.1			
1150	IRO	TRAV	53.1	04-Feb-16	XKS526	53.1			
1160	IRO	TRAV	53.1	04-Feb-16	XKS526	53.1			
1170	IRO	TRAV	53.1	04-Feb-16	XKS526	53.1			
1180	IRO	TRAV	53.1	04-Feb-16	XKS526	53.1			
1190	IRO	TRAV	53.1	05-Feb-16	XKS527	53.1			
1200	IRO	TRAV	53.1	05-Feb-16	XKS527	53.1			

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TERRAQUEST JOB LOG - B346/Quetico - MAG-RAD-(XDS/VLF)- C-GXKS 13/04/2016

LINE	BLK	TYPE	KMS (FLIGHT PLAN)	DATE FLOWN	FLIGHT	KMS FLOWN	REFLIGHT	KMS	COMMENTS
1210	IRO	TRAV	53.1	05-Feb-16	XKS527	53.1			
1220	IRO	TRAV	53.1	05-Feb-16	XKS527	53.1			
1230	IRO	TRAV	53.1	05-Feb-16	XKS527	53.1			
1240	IRO	TRAV	53.1	05-Feb-16	XKS527	53.1			
1250	IRO	TRAV	53.1	05-Feb-16	XKS527	53.1			
1260	IRO	TRAV	53.1	05-Feb-16	XKS527	53.1			
1270	IRO	TRAV	53.1	06-Feb-16	XKS528	53.1			
1280	IRO	TRAV	53.1	06-Feb-16	XKS528	53.1			
1290	IRO	TRAV	53.1	06-Feb-16	XKS528	53.1			
1300	IRO	TRAV	53.1	06-Feb-16	XKS528	53.1			
1310	IRO	TRAV	53.1	06-Feb-16	XKS528	53.1			
1320	IRO	TRAV	53.1	06-Feb-16	XKS528	53.1			
1330	IRO	TRAV	53.1	06-Feb-16	XKS528	53.1			
1340	IRO	TRAV	53.1	06-Feb-16	XKS528	53.1			
1350	IRO	TRAV	53.1	06-Feb-16	XKS528	53.1			
1360	IRO	TRAV	53.1	06-Feb-16	XKS528	53.1			
1370	IRO	TRAV	53.1	06-Feb-16	XKS528	53.1			
1380	IRO	TRAV	53.1	06-Feb-16	XKS528	53.1			
1390	IRO	TRAV	53.1	06-Feb-16	XKS528	53.1			
1400	IRO	TRAV	53.1	06-Feb-16	XKS528	53.1			
1410	IRO	TRAV	53.1	06-Feb-16	XKS528	53.1			
1420	IRO	TRAV	53.1	06-Feb-16	XKS528	53.1			
1430	IRO	TRAV	53.1	06-Feb-16	XKS529	53.1			
1440	IRO	TRAV	53.1	06-Feb-16	XKS529	53.1			
1450	IRO	TRAV	53.1	06-Feb-16	XKS529	53.1			
1460	IRO	TRAV	53.1	06-Feb-16	XKS529	53.1			
1470	IRO	TRAV	53.1	06-Feb-16	XKS529	53.1			
1480	IRO	TRAV	53.1	06-Feb-16	XKS529	53.1			
1490	IRO	TRAV	53.1	06-Feb-16	XKS529	53.1			
1500	IRO	TRAV	53.1	06-Feb-16	XKS529	53.1			
1510	IRO	TRAV	53.1	06-Feb-16	XKS529	53.1			
1520	IRO	TRAV	53.1	06-Feb-16	XKS529	53.1			
1530	IRO	TRAV	45.9	07-Feb-16	XKS530	45.9			
1540	IRO	TRAV	45.9	07-Feb-16	XKS530	45.9			
1550	IRO	TRAV	45.9	07-Feb-16	XKS530	45.9			
1560	IRO	TRAV	45.9	07-Feb-16	XKS530	45.9			
1570	IRO	TRAV	45.9	07-Feb-16	XKS530	45.9			
1580	IRO	TRAV	45.9	07-Feb-16	XKS530	45.9			
1590	IRO	TRAV	45.9	07-Feb-16	XKS530	45.9			
1600	IRO	TRAV	45.9	07-Feb-16	XKS530	45.9			
1610	IRO	TRAV	45.9	07-Feb-16	XKS530	45.9			
1620	IRO	TRAV	45.9	07-Feb-16	XKS530	45.9			
1630	IRO	TRAV	45.9	09-Feb-16	XKS531	45.9			Snow cover?
1640	IRO	TRAV	45.9	09-Feb-16	XKS531	45.9			Snow cover?
1650	IRO	TRAV	45.9	10-Feb-16	XKS532	45.9			
1660	IRO	TRAV	45.9	10-Feb-16	XKS532	45.9			
1670	IRO	TRAV	45.9	10-Feb-16	XKS532	45.9			
1680	IRO	TRAV	45.9	10-Feb-16	XKS532	45.9			
1690	IRO	TRAV	45.9	10-Feb-16	XKS532	45.9			
1700	IRO	TRAV	45.9	10-Feb-16	XKS532	45.9			
1710	IRO	TRAV	45.9	10-Feb-16	XKS532	45.9			
1720	IRO	TRAV	45.9	10-Feb-16	XKS532	45.9			
1730	IRO	TRAV	45.9	10-Feb-16	XKS532	45.9			
1740	IRO	TRAV	45.9	10-Feb-16	XKS532	45.9			
1750	IRO	TRAV	45.9	10-Feb-16	XKS532	45.9			
1760	IRO	TRAV	45.9	10-Feb-16	XKS532	45.9			
1770	IRO	TRAV	45.9	12-Feb-16	XKS534	45.9			
1780	IRO	TRAV	45.9	12-Feb-16	XKS534	45.9			
1790	IRO	TRAV	45.9	12-Feb-16	XKS534	45.9			
1800	IRO	TRAV	45.9	12-Feb-16	XKS534	45.9			
1810	IRO	TRAV	45.9	12-Feb-16	XKS534	45.9			
1820	IRO	TRAV	45.9	12-Feb-16	XKS534	45.9			
1830	IRO	TRAV	45.9	12-Feb-16	XKS534	45.9			
1840	IRO	TRAV	45.9	12-Feb-16	XKS534	45.9			
1850	IRO	TRAV	45.9	12-Feb-16	XKS534	45.9			
1860	IRO	TRAV	45.9	12-Feb-16	XKS534	45.9			
1870	IRO	TRAV	45.9	12-Feb-16	XKS534	45.9			
1880	IRO	TRAV	45.9	12-Feb-16	XKS534	45.9			
1890	IRO	TRAV	45.9	12-Feb-16	XKS534	45.9			
1900	IRO	TRAV	45.9	12-Feb-16	XKS534	45.9			
1910	IRO	TRAV	45.9	12-Feb-16	XKS534	45.9			
1920	IRO	TRAV	45.9	12-Feb-16	XKS534	45.9			
1930	IRO	TRAV	45.9	12-Feb-16	XKS535	45.9			
1940	IRO	TRAV	45.9	12-Feb-16	XKS535	45.9			
1950	IRO	TRAV	45.9	12-Feb-16	XKS535	45.9			
1960	IRO	TRAV	45.9	12-Feb-16	XKS535	45.9			
1970	IRO	TRAV	45.9	12-Feb-16	XKS535	45.9			
1980	IRO	TRAV	45.9	12-Feb-16	XKS535	45.9			
1990	IRO	TRAV	45.9	12-Feb-16	XKS535	45.9			
2000	IRO	TRAV	45.9	12-Feb-16	XKS535	45.9			

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TERRAQUEST JOB LOG - B346/Quetico - MAG-RAD-(XDS/VLF)- C-GXKS 13/04/2016

LINE	BLK	TYPE	KMS (FLIGHT PLAN)	DATE FLOWN	FLIGHT	KMS FLOWN	REFLIGHT	KMS	COMMENTS
2010	IRO	TRAV	45.9	12-Feb-16	XKS535	45.9			
2020	IRO	TRAV	45.9	12-Feb-16	XKS535	45.9			
2030	IRO	TRAV	45.9	13-Feb-16	XKS536	45.9	XKS538	45.9	TF3:4D! (southbound)
2040	IRO	TRAV	45.9	13-Feb-16	XKS536	45.9			
2050	IRO	TRAV	45.9	13-Feb-16	XKS536	45.9	XKS538	45.9	TF3:4D! (southbound)
2060	IRO	TRAV	45.9	13-Feb-16	XKS536	45.9			
2070	IRO	TRAV	45.9	13-Feb-16	XKS536	45.9	XKS538	45.9	TF3:4D! (southbound)
2080	IRO	TRAV	45.9	13-Feb-16	XKS536	45.9			
2090	IRO	TRAV	45.9	13-Feb-16	XKS536	45.9	XKS538	45.9	TF3:4D! (southbound)
2100	IRO	TRAV	45.9	13-Feb-16	XKS536	45.9			
2110	IRO	TRAV	45.9	13-Feb-16	XKS536	45.9	XKS538	45.9	TF3:4D! (southbound)
2120	IRO	TRAV	45.9	13-Feb-16	XKS536	45.9			
2130	IRO	TRAV	45.9	13-Feb-16	XKS536	45.9	XKS538	45.9	TF3:4D! (southbound)
2140	IRO	TRAV	45.9	13-Feb-16	XKS536	45.9			
2150	IRO	TRAV	45.9	13-Feb-16	XKS537	45.9			
5010	IRO	TIE	31.9	11-Feb-16	XKS533	31.9			
5020	IRO	TIE	31.9	11-Feb-16	XKS533	31.9			
5030	IRO	TIE	65.0	11-Feb-16	XKS533	65.0			
5040	IRO	TIE	65.0	11-Feb-16	XKS533	65.0			
5050	IRO	TIE	65.0	11-Feb-16	XKS533	65.0			
5060	IRO	TIE	65.0	11-Feb-16	XKS533	65.0			
5070	IRO	TIE	65.0	11-Feb-16	XKS533	65.0			
5080	IRO	TIE	65.0	11-Feb-16	XKS533	65.0			
5090	IRO	TIE	65.0	11-Feb-16	XKS533	65.0			
5100	IRO	TIE	65.0	11-Feb-16	XKS533	65.0			
5110	IRO	TIE	65.0	11-Feb-16	XKS533	65.0			
5120	IRO	TIE	51.6	11-Feb-16	XKS533	51.6			
5130	IRO	TIE	51.6	11-Feb-16	XKS533	51.6			
5140	IRO	TIE	51.6	11-Feb-16	XKS533	51.6			
5150	IRO	TIE	51.6	13-Feb-16	XKS537	51.6			
5160	IRO	TIE	36.6	13-Feb-16	XKS537	36.6			
5170	IRO	TIE	36.6	13-Feb-16	XKS537	36.6			
5180	IRO	TIE	36.6	13-Feb-16	XKS537	36.6			

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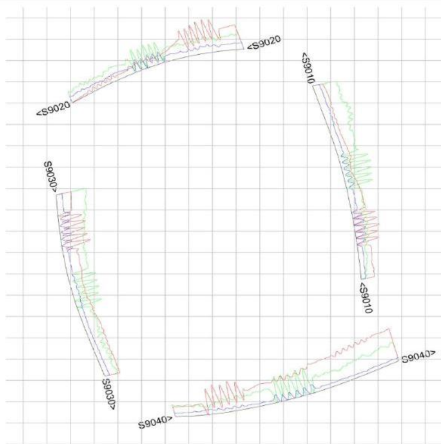
9.3. APPENDIX III – FIGURE OF MERIT

USGS - Ironton Project, Mo

Magnetic Figure of Merit Analysis (SRCDAT:D051423)

Job Ref:	B438	Date:	5-Jan-16	Aircraft:	C-GXKS
Location :	Pre-Survey Qualification: Farmington, Mo				

Flight Path + Manoevers



FOM Index : Sensor 1

Calculation note: Residual noise was isolated using a 75 pt Hanning high pass convolution filter with a subsequent low-pass filter (2.0 fid cutoff) applied to reduce non-related HF noise. Individual min-max values determined from the maximum consecutive peak-to-trough residual noise amplitude within each manoevre group

LINE	DIR	TRAV FLG	PITCH		ROLL		YAW			P	R	Y	Σ
			MAX	MIN	MAX	MIN	MAX	MIN					
9050	N		0.0678	-0.0756	0.0991	-0.0866	0.0438	0.0045		0.1434	0.1857	0.0393	0.3684
9060	W		0.0555	-0.0628	0.0447	-0.0317	0.0509	-0.0831		0.1183	0.0764	0.1340	0.3287
9070	S		0.1731	-0.0692	0.0191	-0.0345	-0.0085	-0.0471		0.2423	0.0536	0.0386	0.3345
9080	E		0.0600	-0.0146	0.0888	0.0128	0.0614	-0.0561		0.0746	0.0760	0.1175	0.2681
									Σ	0.5786	0.3917	0.3294	1.2997
								Full FOM Index :		1.2997			
								Eq. Traverse FOM Index (Σ Trav x 2) :		1.4058			

FOM Index : Sensor 2

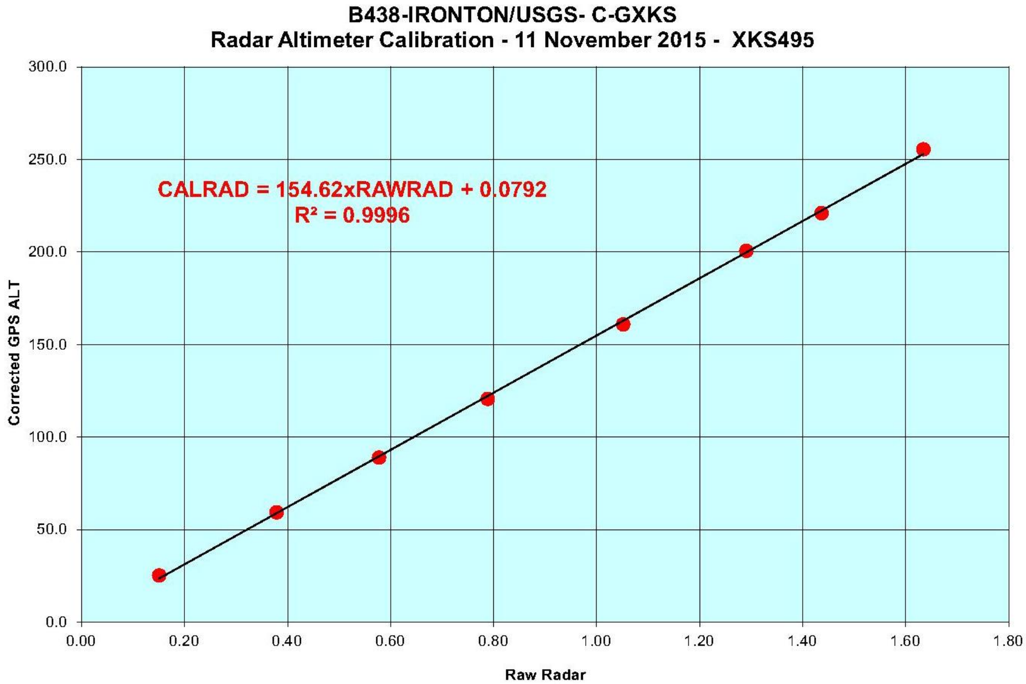
LINE	DIR	TRAV FLG	PITCH		ROLL		YAW			P	R	Y	Σ
			MAX	MIN	MAX	MIN	MAX	MIN					
9050	N		0.0176	-0.0280	0.0361	-0.0215	0.0618	-0.0403		0.0456	0.0576	0.1021	0.2053
9060	W		0.0256	-0.0219	0.0219	-0.0285	0.0310	-0.0483		0.0475	0.0504	0.0793	0.1772
9070	S		0.2211	-0.0519	0.0110	-0.0421	-0.0082	-0.0388		0.2730	0.0531	0.0306	0.3567
9080	E		0.0374	-0.0276	0.0863	-0.0076	0.0149	-0.0170		0.0650	0.0939	0.0319	0.1908
									Σ	0.4311	0.2550	0.2439	0.9300
								Full FOM Index :		0.9300			
								Eq. Traverse FOM Index (Σ Trav x 2) :		1.1240			

FOM Index : Sensor3

LINE	DIR	TRAV FLG	PITCH		ROLL		YAW			P	R	Y	Σ
			MAX	MIN	MAX	MIN	MAX	MIN					
9050	N		0.0323	-0.0671	0.0488	-0.0242	0.0294	0.0027		0.0994	0.0730	0.0267	0.1991
9060	W		0.0139	-0.0055	0.0460	-0.0357	-0.0008	-0.0329		0.0194	0.0817	0.0321	0.1332
9070	S		0.2243	-0.0790	0.0190	-0.0167	-0.0110	-0.0435		0.3033	0.0357	0.0325	0.3715
9080	E		0.0537	0.0103	0.0586	0.0246	0.0027	-0.0133		0.0434	0.0340	0.0160	0.0934
									Σ	0.4655	0.2244	0.1073	0.7972
								Full FOM Index :		0.7972			
								Eq. Traverse FOM Index (Σ Trav x 2) :		1.1412			

9.4. APPENDIX IV – RADAR ALTIMETER CALIBRATION

Terraquest LTD Radar Altimeter Calibration 13/04/2016



Terraquest LTD Radar Altimeter Calibration 13/04/2016

C-GXKS: RADAR CALIBRATION DATA SUMMARY
Calibration performed: CYCN, 11 November 2015, XKS495 - Job Ref B438-Ironton

					INTERCEPT	0.0792
					SLOPE	154.617932
LINE	RAW RADAR	GPS ALT	CORRECTED GPS ALT	RAW RADAR	CALIBRATED RADAR	ERROR *
Ground Ref		267.6	0.0			
S12100	0.1510	292.7	25.1	0.1510	23.4	-1.7
S12200	0.3790	326.8	59.2	0.3790	58.7	-0.5
S12300	0.5780	356.4	88.8	0.5780	89.4	0.6
S12400	0.7890	388.1	120.5	0.7890	122.1	1.6
S12500	1.0520	428.4	160.8	1.0520	162.7	1.9
S12600	1.2910	468.1	200.5	1.2910	199.7	-0.8
S12700	1.4370	488.5	220.9	1.4370	222.3	1.4
S12800	1.6350	523.0	255.4	1.6350	252.9	-2.5

** Error estimated as (Calibrated Radar) - (Corrected GPS Alt)*

o

Imperial Units		
LINE	GPS_ALT (ft)	CAL_RAD (ft)
S12100	82.3	76.9
S12200	194.2	192.5
S12300	291.3	293.5
S12400	395.3	400.5
S12500	527.6	533.9
S12600	657.8	655.2
S12700	724.7	729.2
S12800	837.9	829.7

9.5. APPENDIX V – DETAILED RADIOMETRIC PROCESSING

As noted in "Section 7.3.2 - NASVD Noise Reduction", enhanced noise reduction techniques were used in the data reduction process in an effort to improve the overall resolution. For the reasons stated in section 7.3.2, radiometric data was split into two streams ("Raw" and "Enhanced") and subjected to the following corrections procedures. Both data streams are delivered in the final data set.

Radiometric data, recorded in its raw state as a 256 channel spectrum (array indices specified as 0:255), are initially integrated into five elemental energy windows as defined below:

Window	Energy Range	Channel Range
Total Count	410 - 2810 keV	034 - 234
Potassium	1370 - 1570 keV	114 - 131
Uranium	1660 - 1860 keV	138 - 155
Thorium	2410 - 2810 keV	201 - 234
Cosmic	3000 - ∞ keV	255

1. 'Live Time' correction

The RSI RSX spectrometer does not suffer from conventional "dead time" and thus no specific correction is required, i.e.:

$$\mathbf{N^1_n = N^0_n}$$

$\mathbf{N^1_n}$ = live time corrected count rate for channel "n"
$\mathbf{N^0_n}$ = raw count rate for channel "n"

2. Cosmic Background correction

Primarily caused by photons generated by cosmic ray interactions with nuclei present in the air, aircraft and detector system, an altitude dependent cosmic component is found in each of the four radioelement windows (TC, K, U and Th). A linear relationship exists between radiation detected in the high energy 'Cosmic' window (>3.0 MeV) and the cosmic component detected in the lower energy windows, i.e.

$$\mathbf{N_n = a_n * COS + b_n}$$

where :

N_n : counts due to Cosmic interaction in channel 'n' (where 'n' is any of TC, K, U or Th)

COS : counts detected in the high energy Cosmic window (>3.0 MeV)

a_n, b_n : linear Cosmic coefficients

The Cosmic coefficients are experimentally determined in a special calibration procedure. Counts are corrected for cosmic radiation by simple application of the above relationship, i.e.

$$\mathbf{N^2_{TC} = N^1_{TC} - (a_{TC}*COS + b_{TC})}$$
$$\mathbf{N^2_{K} = N^1_{K} - (a_{K}*COS + b_{K})}$$
$$\mathbf{N^2_{U} = N^1_{U} - (a_{U}*COS + b_{U})}$$
$$\mathbf{N^2_{Th} = N^1_{Th} - (a_{Th}*COS + b_{Th})}$$

As a by-product of this operation, background levels of radiation associated with the aircraft are automatically removed since these levels are represented by the $b_{TC,K,U,Th}$ coefficients.

3. Atmospheric Background correction

A background component, primarily due airborne Radon daughter products, can remain in each of the radioelement windows. The level of background radiation is expected to vary temporally and geographically since the distribution of airborne sources depends on a host of factors such as atmospheric conditions, local ground conditions, etc.

Residual background levels of radiation were determined from data acquired on daily background test lines (flown at 1800 feet where geologic signal contributions are negligible). The data was corrected for Cosmic and Aircraft sources to estimate the remaining atmospheric radiation component.

4. Compton Scatter correction

A gamma ray photon of a particular energy may collide with an electron, impart some of its energy to that electron, and be scattered as a lower energy photon. This phenomena - known as Compton Scattering - will cause some incident photons to be wrongly classified as lower energy events. The practical result of this phenomenon is that, for example, a fraction of incoming Thorium radiation will appear in the Uranium and Potassium energy windows, and a fraction of incoming Uranium radiation will appear in the Potassium window. A very small amount of Uranium radiation may also be 'back-scattered' to the Thorium window. Effectively a channel interaction, this is corrected for by the application of Compton Stripping ratios. Corrected Potassium, Uranium and Thorium count-rates are calculated by application of the following relations:

$$\mathbf{N^4_{Th} = (N^3_{Th} - a*N^3_U) / (1 - a*\alpha)}$$
$$\mathbf{N^4_U = (N^3_U - \alpha*N^3_{Th}) / (1 - a*\alpha)}$$
$$\mathbf{N^4_K = (N^3_K - \beta*N^4_{Th} - \gamma*N^4_U)}$$
$$\mathbf{N^4_{TC} = N^3_{TC}}$$

where :

N^4_n : Compton corrected count-rate for channel ‘n’ (‘n’ is TC, K, U or Th - as indicated)
N^3_n : background corrected count-rate for channel ‘n’ (‘n’ is TC, K, U or Th - as indicated)

α : Th $\rightarrow$ U stripping ratio
β : Th $\rightarrow$ K stripping ratio
γ : U $\rightarrow$ K stripping ratio
a : U $\rightarrow$ Th stripping ratio (“back-scatter”)

Values for each of the four Compton stripping ratios are determined by formal calibration on standardized radiometric calibration pads. Prior to use in the above relation, the α,β and γ coefficients (originally determined at ground level) are adjusted for aircraft terrain clearance by applying the following corrections:

$$\gamma = \gamma + 0.00049*h_{STP}$$
$$\beta = \beta + 0.00065*h_{STP}$$
$$\gamma = \gamma + 0.00069*h_{STP}$$

Where h_{STP} is the aircraft terrain clearance corrected to standard temperature and pressure (see step 5 following).

5. Altitude Attenuation correction

Within the terrain clearances normally encountered in airborne radiometric surveys, ground originating radiation is assumed to attenuate exponentially with distance from source, i.e.

$$\mathbf{N_h = N_0 e^{-\mu h}}$$

where :

N_h : count-rate at **height = h**
N_0 : count-rate at **height = 0**
μ : altitude attenuation coefficient

The attenuation coefficients, which are specific to each of the four radioelement windows, are evaluated using data from a special calibration exercise (see ***9.8 Appendix VIII: Altitude Attenuation***).

Variation due to terrain clearance is removed from the data by applying the simple relationship noted above in the following manner:

$$\mathbf{N^5_n = N^4_n * e^{-\mu n(hs\ -\ hstp)}}$$

where :

N^5_n : height corrected count-rate for channel 'n' ('n' is any of TC, K, U or Th)
N^4_n : Compton corrected count-rate for channel 'n' (note that Compton corrections do not apply to Total Count so that N^4_1 is, in fact, the un-modified N^3_1)
μ_n : altitude attenuation coefficient for channel 'n'
h_s : nominal survey terrain clearance
h_{stp} : actual terrain clearance corrected to STP

Indicated terrain clearance is first corrected to standard temperature (flight logs) and calculated pressure (Pressure=101325*(1-0.00002255778AH)$^{5.25588}$ by applying the following steps:

h_{stp} = (h*273.15*P)/[(T+273.15)*P_{sl}]

where:

h_{stp} = corrected terrain clearance
h = measured terrain clearance
P = measured atmospheric pressure, in mB
T = temperature, in degrees Celsius
P_{sl} = sea-level pressure (=1013.25 mB)

When interpreting height corrected data, care should be taken where terrain clearances significantly exceed the nominal (or programmed) survey clearance since count-rates tend to be artificially boosted due to the exponential nature of the correction algorithm.

6. Sensitivity Factors

Corrected ROI (TC, K, U, Th) channel data in counts per second were converted to concentration units (respectively nGy/h, %K, ppm eU, ppm eTh) by application of sensitivity factors determined during a calibration flight over the Breckenridge Calibration Range located near Ottawa Canada (see ***9.9 Appendix IX – Sensitivity Factors***)

9.6. APPENDIX VI – COSMIC CALIBRATION

TERRAQUEST LTD COSMIC ALTITUDE DEPENDENCE

B438-IRONTON / C-GXKS : COSMIC CALIBRATION
-performed 19 December, 2015 / XKS504 / Farmington, Mo

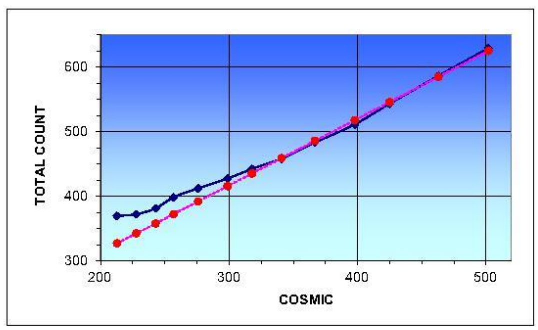
LINE	GPS ALT metres	TC cps	K cps	U cps	TH cps	U UP	COSMIC cps
S804000	1375.4	369.0	26.0	18.0	12.0	5.0	213.0
S804500	1521.9	372.0	26.0	17.0	13.0	4.0	228.0
S805000	1669.7	381.0	27.0	18.0	14.0	5.0	243.0
S805500	1809.3	398.0	27.0	18.0	15.0	5.0	257.0
S806000	1968.8	412.0	28.0	19.0	16.0	5.0	276.0
S806500	2114.8	427.0	30.0	19.0	18.0	5.0	299.0
S807000	2269.4	442.0	30.0	21.0	19.0	5.0	318.0
S807500	2414.7	458.0	31.0	20.0	21.0	5.0	341.0
S808000	2571.2	483.0	32.0	22.0	23.0	6.0	367.0
S808500	2723.3	511.0	34.0	23.0	24.0	6.0	398.0
S809000	2876.7	543.0	36.0	24.0	26.0	6.0	425.0
S809500	3041.3	586.0	39.0	26.0	28.0	7.0	463.0
S810000	3207.6	629.0	41.0	29.0	31.0	7.0	502.0

COSMIC COEFFICIENTS
$COS\_COMPONENT_n = a_n COSMIC + b_n$

	Slope (a_n)	Intercept (b_n)
Total Count	1.0324	106.6755
Potassium	0.0624	9.6161
Uranium	0.0454	5.3293
Thorium	0.0620	-0.3431
Uranium UP	0.0116	1.3170

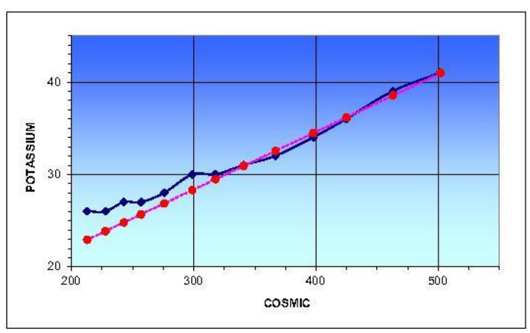
TOTAL COUNT COSMIC DEPENDENCE

COSMIC	TC	TC FIT
213.0	369.0	326.6
228.0	372.0	342.1
243.0	381.0	357.6
257.0	398.0	372.0
276.0	412.0	391.6
299.0	427.0	415.4
318.0	442.0	435.0
341.0	458.0	458.7
367.0	483.0	485.6
398.0	511.0	517.6
425.0	543.0	545.5
463.0	586.0	584.7
502.0	629.0	625.0



POTASSIUM COSMIC DEPENDENCE

COSMIC	K	K FIT
213.0	26.0	22.9
228.0	26.0	23.9
243.0	27.0	24.8
257.0	27.0	25.7
276.0	28.0	26.8
299.0	30.0	28.3
318.0	30.0	29.5
341.0	31.0	30.9
367.0	32.0	32.5
398.0	34.0	34.5
425.0	36.0	36.2
463.0	39.0	38.5
502.0	41.0	41.0



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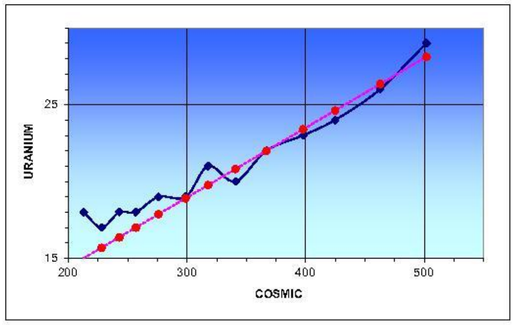
TERRAQUEST LTD COSMIC ALTITUDE DEPENDENCE

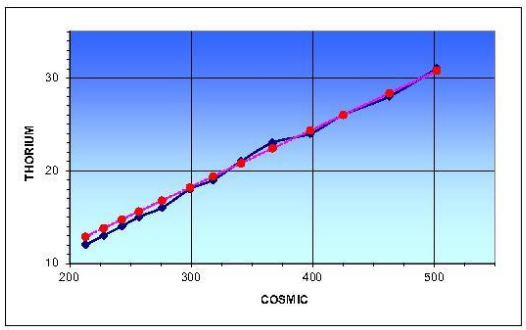
URANIUM COSMIC DEPENDENCE

COSMIC	U	U FIT
213.0	18.0	15.0
228.0	17.0	15.7
243.0	18.0	16.4
257.0	18.0	17.0
276.0	19.0	17.9
299.0	19.0	18.9
318.0	21.0	19.8
341.0	20.0	20.8
367.0	22.0	22.0
398.0	23.0	23.4
425.0	24.0	24.6
463.0	26.0	26.3
502.0	29.0	28.1



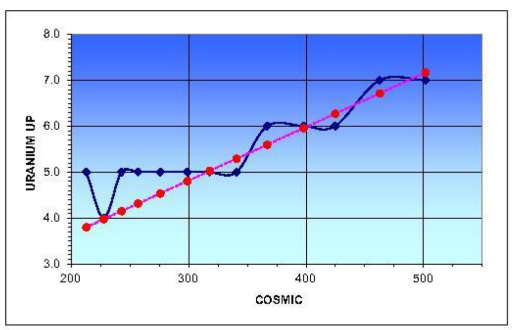
THORIUM COSMIC DEPENDENCE

COSMIC	TH	TH FIT
213.0	12.0	12.9
228.0	13.0	13.8
243.0	14.0	14.7
257.0	15.0	15.6
276.0	16.0	16.8
299.0	18.0	18.2
318.0	19.0	19.4
341.0	21.0	20.8
367.0	23.0	22.4
398.0	24.0	24.3
425.0	26.0	26.0
463.0	28.0	28.4
502.0	31.0	30.8



URANIUM UP COSMIC DEPENDENCE

COSMIC	UUP	UUP FIT
213.0	5.0	3.8
228.0	4.0	4.0
243.0	5.0	4.1
257.0	5.0	4.3
276.0	5.0	4.5
299.0	5.0	4.8
318.0	5.0	5.0
341.0	5.0	5.3
367.0	6.0	5.6
398.0	6.0	6.0
425.0	6.0	6.3
463.0	7.0	6.7
502.0	7.0	7.2



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9.7. APPENDIX VII – COMPTON COEFFICIENTS

RADIATION SOLUTIONS INC

CALIBRATION SHEET

Instrument: **RSX-5**

Customer:	Terraquest	Date:	July 15, 2015
Contact:	Charles Barrie	Tech.:	Jim C
Console :	N/A	Job Order:	RMA# 10691
Detector 1:	5588	Customer PO	PO#
Detector 2:	N/A		

Channels: 1024 **ADC Offset:** N/A

	A1	A2	A3	A4	A5
High Voltages	656	711	642	627	668

Stripping Constant	"this system"	"normal"
Alpha	**0.283**	0.250
Beta	**0.412**	0.400
Gamma	**0.768**	0.810
a	**0.043**	0.060
b	**-0.001**	0.000
g	**0.002**	0.003

ROI#	Channel	IAEA Specification [keV]	Label
1	137-937	410-2810	Total Count
2	457-523	1370-1570	Potassium K
3	553-620	1660-1860	Uranium U
4	803-937	2410-2810	Thorium Th
5			
6			
7			
8	553-620	1660-1860	Uranium Upper U

Det#	Peak Cs	Cs FWHM		Peak Th	Th FWHM
A1	219.12	7.82		872.65	4.36
A2	219.26	8.49		871.76	5.10
A3	218.81	8.16		871.25	4.72
A4	220.99	7.16		873.66	4.36
Sum Dn	**219.62**	**7.96**		**872.42**	**4.60**
Sum Up	**219.05**	**8.46**		**872.54**	**5.05**

386 Watline Avenue Mississauga ♦ Ontario Canada L4Z 1X2 ♦ Tel (905) 890 1111 ♦ Fax (905) 890 1964 ♦ e-mail sales@radiationsolutions.ca

RADIATION SOLUTIONS INC

CALIBRATION SHEET

Instrument: **RSX-5**

Customer:	Terraquest	Date:	July 15, 2015
Contact:	Charles Barrie	Tech.:	Jim C
Console :	N/A	Job Order:	RMA# 10691
Detector 1:	5587	Customer PO	PO#
Detector 2:	N/A		

Channels: 1024 **ADC Offset:** N/A

	A1	A2	A3	A4	A5
High Voltages	672	714	652	659	657

Stripping Constant	"this system"	"normal"
Alpha	**0.285**	0.250
Beta	**0.406**	0.400
Gamma	**0.762**	0.810
a	**0.047**	0.060
b	**-0.001**	0.000
g	**0.002**	0.003

ROI#	Channel	IAEA Specification [keV]	Label
1	137-937	410-2810	Total Count
2	457-523	1370-1570	Potassium K
3	553-620	1660-1860	Uranium U
4	803-937	2410-2810	Thorium Th
5			
6			
7			
8	553-620	1660-1860	Uranium Upper U

Det#	Peak Cs	Cs FWHM		Peak Th	Th FWHM
A1	219.40	7.76		871.64	4.38
A2	219.36	8.21		871.86	4.77
A3	219.32	8.25		872.34	4.81
A4	219.37	8.13		872.02	4.74
Sum Dn	**219.36**	**8.08**		**871.94**	**4.65**
Sum Up	**218.96**	**8.54**		**872.36**	**5.00**

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	C-GXKS: RADIOMETRIC PAD CALIBRATION - at RSI, 15 JUNE 2015						
	DET 1 RSX-5 s/n 5587	DET 2 RSX-5 s/n 5588	DET AVE		LAST	POOR	IDEAL
ALPHA	0.2850	0.2830	**0.2840**			0.3800	0.2500
BETA	0.4060	0.4120	**0.4090**			0.4300	0.4000
GAMMA	0.7620	0.7680	**0.7650**			0.9200	0.8100
a	0.0470	0.0430	**0.0450**			0.0900	0.0600
b	-0.0010	-0.0010	**-0.0010**			0.0100	0.0000
g	0.0020	0.0020	**0.0020**			0.0600	0.0030

9.8. APPENDIX VIII– ALTITUDE ATTENUATION

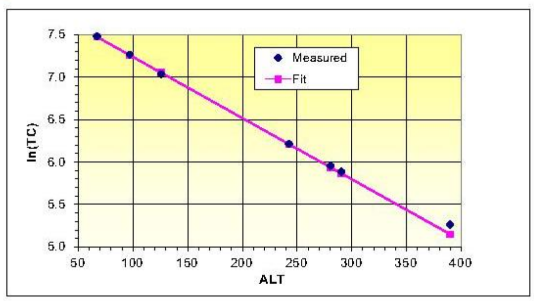
The following presents the calculation of the four sets of altitude attenuation correction coefficients (Total Count, Potassium, Uranium and Thorium) using data acquired at Breckenridge ON on July 28, 2015.

TERRAQUEST C-GXKS / RSI 2xRSX5 RADIOMETRIC ALTITUDE ATTENUATION CALIBRATION *RSX5-5587, RSX5-5588 - Breckenridge - 28 July 2015*					
LINE	Average Clearance, STP Corrected (metres)	TC (cor. CPS)	K (cor. CPS)	U (cor. CPS)	TH (cor. CPS)
S2100	67.3	1772.2	181.3	14.3	44.6
S3100	97.3	1421.8	138.1	11.7	36.2
S4100	125.8	1130.5	103.6	8.6	30.0
S5100	242.8	498.7	36.7	3.4	13.8
S6100	290.4	359.2	25.0	2.3	10.2
S7100	280.5	385.0	26.4	2.9	10.4
S8100	390.0	192.7	12.3	1.4	5.6

ALTITUDE ATTENUATION COEFFICIENTS *Calculated by LSQ fit to : ln(N) = ALT*μ + ln(N₀) relation*						
TC	μ_{TC} =	-0.007207	$\ln(N_0)_{TC}$ =	7.9561	R^2 Corr Coeff	0.9988
K	μ_{K} =	-0.009093	$\ln(N_0)_{K}$ =	5.8048	R^2 Corr Coeff	0.9963
U	μ_{U} =	-0.008265	$\ln(N_0)_{U}$ =	3.2254	R^2 Corr Coeff	0.9904
Th	μ_{Th} =	-0.006666	$\ln(N_0)_{Th}$ =	4.2416	R^2 Corr Coeff	0.9986

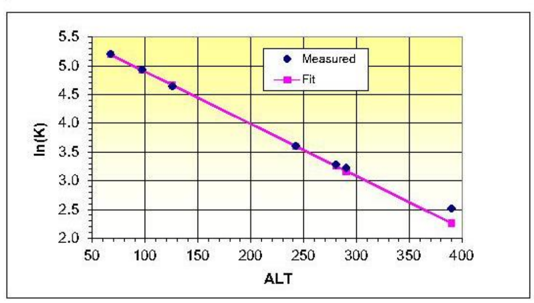
ALTITUDE DEPENDENCE: TOTAL COUNT

ALT	ln(N)	FIT
67.3	7.4800	7.4710
97.3	7.2597	7.2552
125.8	7.0304	7.0495
242.8	6.2120	6.2064
290.4	5.8839	5.8632
280.5	5.9532	5.9346
390.0	5.2611	5.1458



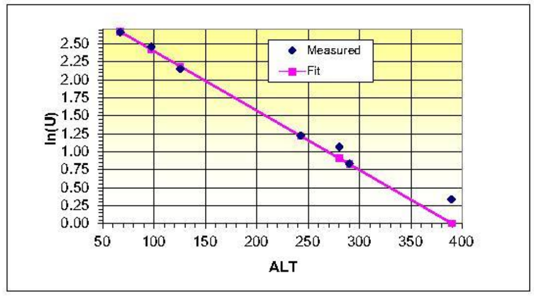
ALTITUDE DEPENDENCE: POTASSIUM

ALT	ln(N)	FIT
67.3	5.2002	5.1928
97.3	4.9280	4.9205
125.8	4.6405	4.6609
242.8	3.6028	3.5973
290.4	3.2189	3.1642
280.5	3.2734	3.2543
390.0	2.5096	2.2591



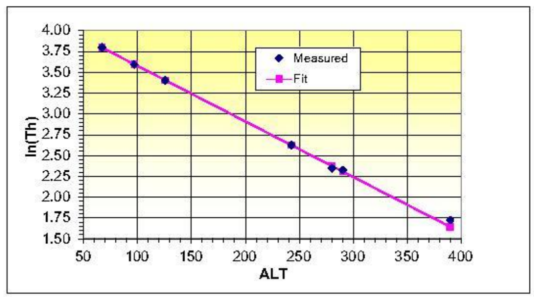
ALTITUDE DEPENDENCE: URANIUM

ALT	ln(N)	FIT
67.3	2.6603	2.6691
97.3	2.4596	2.4216
125.8	2.1518	2.1857
242.8	1.2238	1.2189
290.4	0.8329	0.8253
280.5	1.0647	0.9072
390.0	0.3365	0.0026



ALTITUDE DEPENDENCE: THORIUM

ALT	ln(N)	FIT
67.3	3.7977	3.7930
97.3	3.5891	3.5933
125.8	3.4012	3.4031
242.8	2.6247	2.6233
290.4	2.3224	2.3058
280.5	2.3418	2.3719
390.0	1.7228	1.6423



9.9. APPENDIX IX – SENSITIVITY FACTORS

Note: Exponential Fit Parameters list the results of applying exponential regression analysis to the experimental data and allow the calculation of system sensitivities at any given altitude: "m" and "b" factors are applied using the general exponential relation $y = b * m^x$. *For example*, given m = 0.9934 and b = 73.5360, the Total Count sensitivity at clearance 80 metres is calculated as $\mathbf{S_{80m} = 73.5360 * 0.9934^{80}}$**.** The Breckenridge calibration was flown on July 28, 2015.

Measured Ground Values:	
Exp (TC) : nGy/hr	46.54
%K	1.51
ppm U	1.57
ppm Th	7.17

C-GXS (RSX5-5587, RSX5-5588) - Breckenridge 28-JULY-2015

Job Ref : B436-Quetico/MNDM (Ground Survey by Nick Bain, RS-230 Calibrated Spectrometer)

**** Radar Altimeter values adjusted to STP

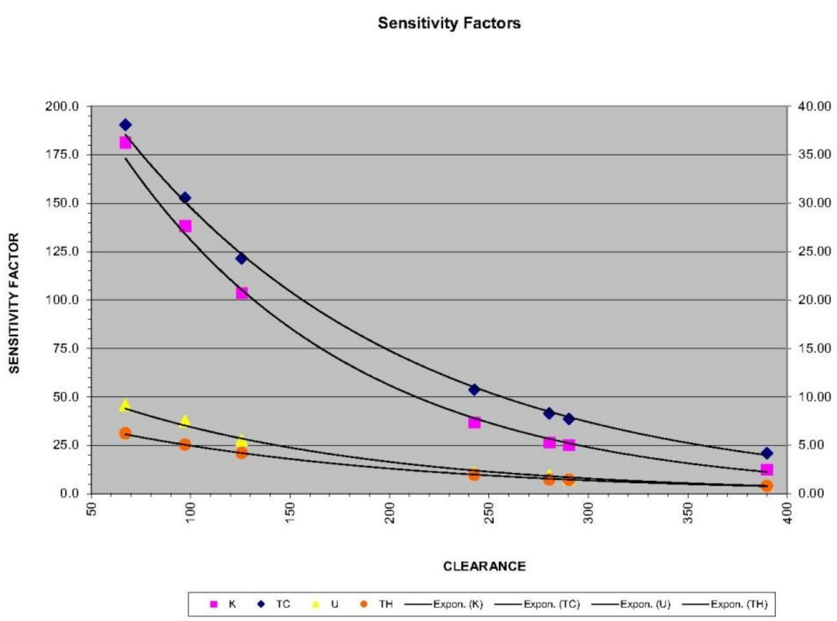
TC,K,U,Th have been stripped with height adjusted values

Total Count calculated as: TC (nGyh) = 13.078*K_pct + 5.675*U_ppm + 2.494*Th_ppm;

Line	Clearance (metres)	TC (cps)	K (cps)	U (cps)	Th (cps)	STC (cps/unit)	SK (cps/unit)	SU (cps/unit)	STH (cps/unit)
S2100	67.3	1772.2	181.3	14.3	44.6	38.08	119.90	9.13	6.22
S3100	97.3	1421.8	138.1	11.7	36.2	30.55	91.33	7.47	5.05
S4100	125.8	1130.5	103.6	8.6	30.0	24.29	68.51	5.49	4.19
S5100	242.8	498.7	36.7	3.4	13.8	10.72	24.27	2.17	1.93
S6100	290.4	359.2	25.0	2.3	10.2	7.72	16.53	1.47	1.42
S7100	280.5	385.0	26.4	2.9	10.4	8.27	17.46	1.85	1.45
S8100	390.0	192.7	12.3	1.4	5.6	4.14	8.13	0.89	0.78

		"m"	"b"
Exponential Fit Parameters:	TC	0.9928	61.3008
	K	0.9909	219.4920
	U	0.9918	16.0621
	TH	0.9934	9.7006

Calculated Sensitivities	
CLEARANCE:	100
TC	29.82
K	88.41
U	7.03
TH	4.98



GROUND SURVEY RESULTS : C-GXKS (RSX5-5587, RSX5-5588) - Breckenridge 28-JULY-2015

Survey by: Nick Bain (Terraquest LTD) Equipment: RS-230 Ground Spectrometer (calibrated July, 2015 at RSI)

SITE	TC	K	U	Th
1	616.2	0.9	1.1	6.5
	627.6	1.0	1.0	6.9
	609.2	1.0	0.1	6.1
	535.7	1.5	0.8	7.4
	540.7	1.5	1.1	7.0
	516.0	1.3	1.2	6.1
2	601.0	1.2	1.3	6.0
	600.5	1.4	1.4	6.7
	577.6	1.4	0.6	6.5
	556.7	1.3	1.0	5.8
	586.6	1.8	1.1	7.9
	559.9	1.8	1.2	6.1
3	686.8	1.7	2.8	6.6
	690.8	1.8	2.5	9.0
	689.4	1.7	1.9	9.0
	659.8	1.7	2.1	7.2
	682.5	1.6	3.2	8.5
	679.1	1.7	3.2	7.3
4	566.1	1.5	1.5	6.3
	573.5	1.5	1.1	6.2
	559.2	1.6	1.3	5.7
	644.6	1.4	1.8	7.6
	651.6	1.6	2.7	8.0
	645.1	1.4	2.4	8.1
6	621.3	1.6	2.8	7.7
	613.1	1.5	1.9	8.4
	601.9	1.6	1.5	7.8
	591.1	1.8	2.0	7.1
	582.5	1.8	1.3	7.3
	591.9	1.8	1.1	8.1
7	547.7	1.5	1.2	7.4
	533.8	1.4	0.7	7.5
	552.1	1.6	0.8	6.7

Total Count	
Mean	602.78
Standard Error	8.75
Median	600.5
Mode	#N/A
Standard Deviation	50.26
Sample Variance	2525.98
Kurtosis	-0.889356368
Skewness	0.306012831
Range	174.8
Minimum	516
Maximum	690.8
Sum	19891.6
Count	33

Potassium	
Mean	1.51
Standard Error	0.04
Median	1.5
Mode	1.5
Standard Deviation	0.24
Sample Variance	0.06
Kurtosis	0.58110329
Skewness	-0.9223731
Range	0.9
Minimum	0.9
Maximum	1.8
Sum	49.9
Count	33

Column1	
Mean	1.57
Standard Error	0.14
Median	1.3
Mode	1.1
Standard Deviation	0.78
Sample Variance	0.61
Kurtosis	-0.30322911
Skewness	0.631442469
Range	3.1
Minimum	0.1
Maximum	3.2
Sum	51.7
Count	33

Thorium	
Mean	7.17
Standard Error	0.16
Median	7.2
Mode	6.1
Standard Deviation	0.91
Sample Variance	0.82
Kurtosis	-0.7160117
Skewness	0.27737695
Range	3.3
Minimum	5.7
Maximum	9
Sum	236.5
Count	33

9.10. APPENDIX X – README FILE

```
USGS Contract Ref: G16PC00002
AIRBORNE MAGNETIC/RADIOMETRIC SURVEY: IRONTON AREA, MISSOUURI

SURVEY PERFORMED BY: TERRAQUEST LTD
TERRAQUEST Ref: B438
DEC,2015 - FEB, 2016

FOLDER: B438_IRONTON\MAGNETICS\DATA
===================================

  Magnetic data archived at 10 samples per second (10Hz, nominal spacing approx 7
metres)
  Geosoft formatted database (.gdb):

  B438_IRONTON_MAG.gdb

  The database contains the following data fields :

    LINE             : Line ID (integer)
    AZIMUTH          : Line Direction (deg N)
    X_UTM15N_WIN     : UTM Easting (WGS84, Zone 15N)
    Y_UTM15N_WIN     : UTM Northing (WGS84, Zone 15N)
    FLIGHT           : Flight Number (integer)
    DATE             : Flight Date (YYYY/MM/DD)
    FID              : Fiducial counter (UTC day-secs)
    TIME             : Time (UTC, HH:MM:SS format)
    RADAR            : Terrain Clearance (metres)
    ALT              : Altitude (WGS84, metres, above geoid)
    DTM              : Calculated Digital Terrain (metres, above geoid)
    DRAPE            : Target Flying Height (metres, above geoid)
    SRTM             : 30m High Resolution Shuttle Radar Topographic Mission elevation
                       Data (metres, above geoid)
    LAT              : Latitude (WGS84 deg)
    LON              : Longitude (WGS84 deg)
    DIURNAL          : Raw Magnetic Diurnal (nT)
    DIUEDIT          : Magnetic Diurnal, cultural events removed (nT)
    VMX              : Fluxgate Magnetometer, X component (nT)
    VMY              : Fluxgate Magnetometer, Y component (nT)
    VMZ              : Fluxgate Magnetometer, Z component (nT)
    VMTF             : Fluxgate Magnetometer, Total Field (nT)
    TF1UNC           : Raw, uncompensated Left Wing Magnetometer (nT)
    TF2UNC           : Raw, uncompensated Right Wing Magnetometer (nT)
    TF3UNC           : Raw, uncompensated Tail Magnetometer (nT)
    TF1CMP           : Raw, compensated Left Wing Magnetometer (nT)
    TF2CMP           : Raw, compensated Right Wing Magnetometer (nT)
    TF3CMP           : Raw, compensated Tail Magnetometer (nT)
    TF1LAG           : Lagged, compensated Left Wing Magnetometer (nT)
    TF2LAG           : Lagged, compensated Right Wing Magnetometer (nT)
    TF3LAG           : Lagged, compensated Tail Magnetometer (nT)
    TF3FNL           : Final, corrected Tail Magnetometer (nT)
    IGRF_DEC         : IGRF Declination (deg, 31-JAN-2016, ref alt 458m)
    IGRF_INC         : IGRF Inclination (deg, 31-JAN-2016, ref alt 458m)
    IGRF_TF          : IGRF Total Field (nT, 31-JAN-2016, ref alt 458m)
    TF3ANM           : Final, corrected, anomalous (IGRF corrected) TMI (nT)
    HGX              : Raw,East-West magnetic gradient (nT/m)
    HGXLAG           : Lag corrected East-West gradient (nT/m)
    HGXML            : Final, median levelled East-West gradient (nT/m)
    HGY              : Raw,North-South magnetic gradient (nT/m)
    HGYLAG           : Lag corrected North-South gradient (nT/m)
    HGYML            : Final, median levelled North-South gradient (nT/m)
```

```
FOLDER: B438_IRONTON\MAGNETICS\GRIDS
====================================

  Supplied data grids: WGS84/Zone 15N projection, 50 metre cell size prepared using
bi-directional, Akima spline interpolation:

  DTM.grd,.gi     : calculated digital terrain (metres, above Geoid, 60 m grid cell
size)
  TMIFNL.grd,.gi  : final, corrected Total Magnetic Intensity (nT)
  TMIANM.grd,.gi  : final, IGRF corrected Total Magnetic Intensity (anomalous TMI, nT,
60 m grid cell size)

  EXTRAS:

  HGX.grd,.gi     : measured East-West magnetic gradient (nT/m)
  HGY.grd,.gi     : measured North-South magnetic gradient (nT/m)
  RTF.grd,.gi     : reconstructed total magnetic field using horizontal gradients*
(pseudo nT)
  TMI1VD.grd,.gi  : first vertical derivative of TMI (nT/m)

  * calculated using method described by Nelson:
```

Nelson, J.B., 1994, Leveling total-field aeromagnetic data with measured horizontal gradients: Geophysics, 59, 1166-1170

```
FOLDER: B438_IRONTON\MAGNETICS\MAPS
======================================

Supplied Maps: WGS84/ZONE 15N projection with topographic underlay

B438_FlightPath_01                    : Flight Path Map
B438_DigitalTerrainModel_02           : Calculated Digital Terrain Model (m above
Geoid)
B438_TotalMagneticIntensity_03        : Corrected Total Magnetic Intensity (nT)
B438_AnomalousMagneticField_04        : IGRF corrected Total Magnetic Intensity (nT)
B438_CalculatedVerticalDerivative_05 : Calculated First Vertical Derivative of TMI
(nT/m)
B438_ReconstructedTotalField_06       : Reconstructed Total Magnetic Field using the
Horizontal gradients

FOLDER: B438_IRONTON\MAGNETICS\JPEGS
======================================

Supplied JPEGS: WGS84/ZONE 15N projection with topographic underlay, 125 DPI

B438_FlightPath_01                    : Flight Path Map
B438_DigitalTerrainModel_02           : Calculated Digital Terrain Model (m above
Geoid)
B438_TotalMagneticIntensity_03        : Corrected Total Magnetic Intensity (nT)
B438_AnomalousMagneticField_04        : IGRF corrected Total Magnetic Intensity (nT)
B438_CalculatedVerticalDerivative_05 : Calculated First Vertical Derivative of TMI
(nT/m)
B438_ReconstructedTotalField_06       : Reconstructed Total Magnetic Field using the
Horizontal gradients
```

```
FOLDER: B438_IRONTON\RADIOMETRICS\DATA
======================================

  Radiometric data archived at 1 sample per second (1Hz, nominal sample spacing
approx. 70 metres)
  Geosoft formatted database (.gdb):


  B438_IRONTON_RAD.gdb

  The database contains the following data fields :

    LINE            : Line ID (integer)
    AZIMUTH         : Line Direction (deg N)
    X_UTM15N_WIN    : UTM Easting (WGS84, Zone 15N)
    Y_UTM15N_WIN    : UTM Northing (WGS84, Zone 15N)
    FLIGHT          : Flight Number (integer)
    DATE            : Flight Date (YYYY/MM/DD)
    FID             : Fiducial counter (UTC day-secs)
    TIME            : Time (UTC, HH:MM:SS format)
    RADAR           : Terrain Clearance (metres)
    ALT             : Altitude (WGS84, metres, above geoid)
    LAT             : Latitude (WGS84 deg)
    LON             : Longitude (WGS84 deg)
    LIVETIM         : Spectrometer Live time (mSec)
    PRESS           : Atmospheric Pressure (mBar)
    TEMP            : Outside Air Temperature (deg C)
    RADSTP          : Terrain Clearance corrected to STP (metres)
    RADON           : Atmospheric Radon Background (cps)
    SPC_DOWN        : Raw, 256 channel downward Gamma Ray spectrum
    SPC_UP          : Raw, 256 channel upward Gamma Ray spectrum
    RAWTC           : Raw Total Count (cps)
    RAWK            : Raw Potassium (cps)
    RAWU            : Raw Uranium (cps)
    RAWTH           : Raw Thorium (cps)
    RAWUUP          : Raw Upward Uranium (cps)
    RAWCOS          : Raw Cosmic (cps)
    NAS_SPC_DOWN    : Noise Reduced (NASVD), 256 downward spectrum
    NAS_SPC_UP      : Noise Reduced (NASVD), 256 upward spectrum
    NAS_RAWK        : Noise Reduced (NASVD), raw Potassium
    NAS_RAWTC       : Noise Reduced (NASVD), raw Total Count
    NAS_RAWTH       : Noise Reduced (NASVD), raw Thorium
    NAS_RAWU        : Noise Reduced (NASVD), raw Uranium
    NAS_RAWUUP      : Noise Reduced (NASVD), raw Uranium (up)
    FK              : Final corrected, Potassium (cps)
    FTC             : Final corrected, Total Count (cps)
    FTH             : Final corrected, Thorium (cps)
    FU              : Final corrected, Uranium (cps)
    SK              : Final corrected, calibrated Potassium (%K)
    STC             : Final corrected, calibrated Total Count (exposure rate: nGy/h)
    STH             : Final corrected, calibrated Thorium (ppm eTh)
    SU              : Final corrected, calibrated Uranium (ppm eU)
```

```
FOLDER: B438_IRONTON\RADIOMETRICS\GRIDS
=======================================

  Supplied data grids: WGS84/Zone 15N projection, 60 metre cell size prepared using
Minimum Curvature grid interpolation:

  POTASSIUM.grd,.gi       : Potassium (%K)
  THORIUM.grd,.gi         : Thorium (ppm eTh)
  TOTALCOUNT.grd,.gi      : Total Count (exposure rate, nGy/h)
  TOTALCOUNT_CPS,.grd.gi  : Total Count (cps)
  URANIUM.grd,gi          : Uranium (ppm eU)

  EXTRAS:

  TERNARY_COLOR_GRID.grd,.gi : Geosoft Color Grid displaying sum-normalised Ternary
                               Radiometrics (pre-processed using Geologic Survey of
                               Canada "S-TRGEN" s/w) - display as "image", Geosoft
                               colour grid format


FOLDER: B438_IRONTON\RADIOMETRICS\MAPS
=======================================

Supplied Maps: WGS84/ZONE 15N projection with topographic underlay

B438_TotalCount_07                    : Total Count (exposure rate, nGy/h)
B438_Potassium_08                     : Potassium (%K)
B438_Uranium_09                       : Uranium (ppm eU))
B438_Thorium_10                       : Thorium (ppm eTh)
B438_Ternary_11                       : Geosoft Color Grid displaying sum-normalised
                                        Ternary Radiometrics (pre-processed using
                                        Geologic Survey of Canada "S-TRGEN" s/w

FOLDER: B438_IRONTON\RADIOMETRICS\JPEGS
======================================

Supplied JPEGS: WGS84/ZONE 15N projection with topographic underlay, 125 DPI

B438_TotalCount_07                    : Total Count (exposure rate, nGy/h)
B438_Potassium_08                     : Potassium (%K)
B438_Uranium_09                       : Uranium (ppm eU))
B438_Thorium_10                       : Thorium (ppm eTh)
B438_Ternary_11                       : Geosoft Color Grid displaying sum-normalised
                                        Ternary Radiometrics (pre-processed using
                                        Geologic Survey of Canada "S-TRGEN" s/w
```